BOSTON UNIVERSITY

GRADUATE SCHOOL

THESIS

A LABORATORY GUIDE IN ELEMENTARY BIOLOGY WITH SPECIAL REFERENCE TO THE BIOTA OF THE WEST INDIES

by

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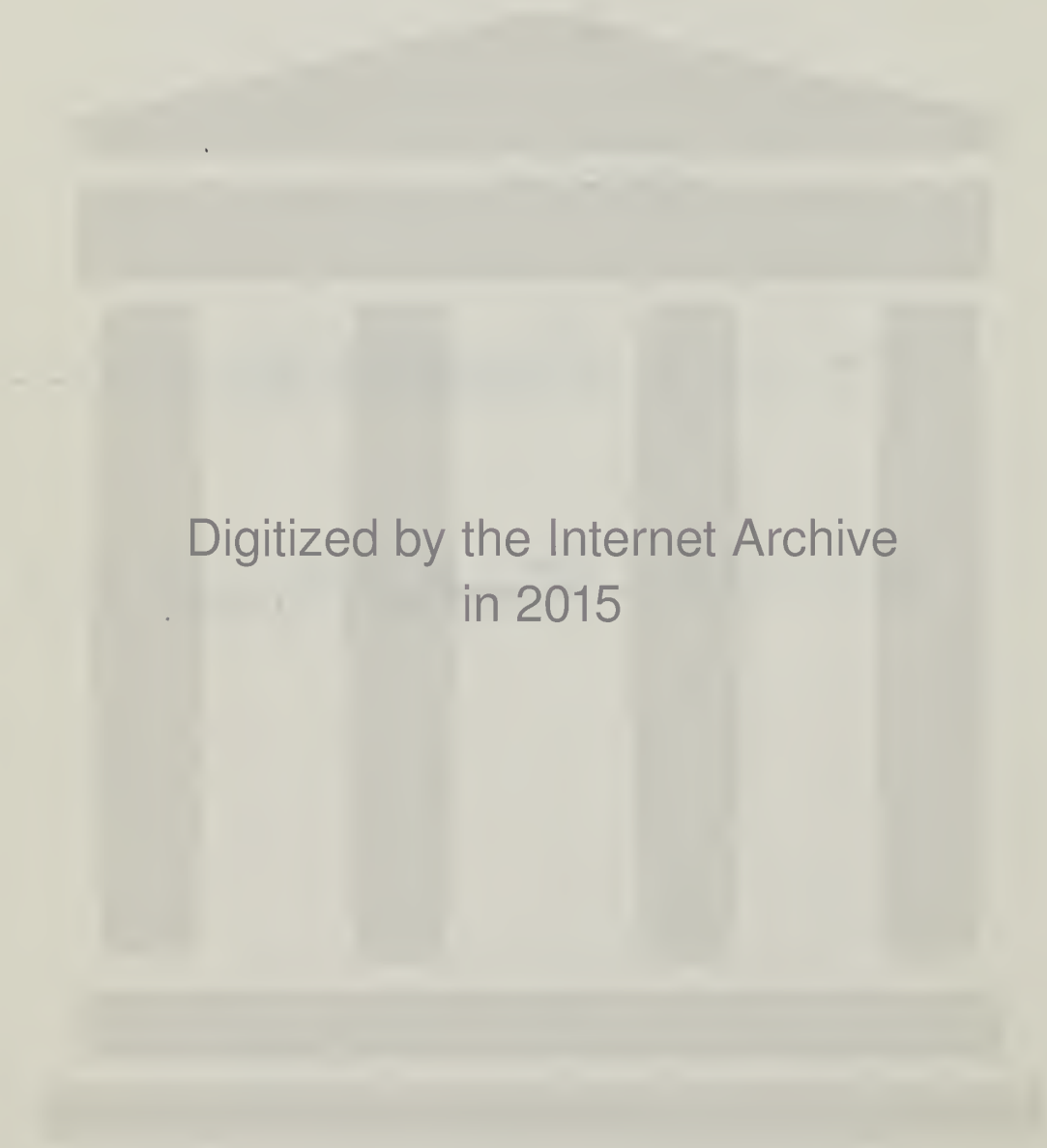

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INTRODUCTION

The purpose of this manual is to serve as a laboratory guide both for students and teachers of elementary biology in the West Indies. An effort has been made to include suitable work for students who are going to college as well as for those who will do no further work in this science. Such units as evolution, heredity, anatomy and physiology will be as interesting and useful as the consideration of different types of living organisms to both types of students.

Perhaps there is not much originality in these directions since many laboratory workbooks are available but this one attempts to use materials from the flora and fauna of the West Indies.

The order in which the exercises have been placed does not follow the order of any specific textbook so they may be chosen in the order that will best suit the teacher's plans.

A few words in regard to general laboratory procedures and records.

There is a recent tendency to eliminate drawings in secondary school biology courses. Personally, I think that they should be simplified but not done away with. Thomas H. Huxley said in his "Science and Art in Education": "I should make it absolutely necessary for everybody, for a longer or shorter period, to learn to draw. Now, you may say, there are some people who cannot draw, however, much they may be taught.

I deny that in toto because I never yet met anybody who could not learn to write. Writing is a form of drawing; therefore if you give the same attention and trouble to drawing as you do to writing, depend upon it, there is nobody who cannot be made to draw more or less well.....I do not say for one moment you would make an artistic draughtsman....but you can teach simple drawing, and you will find it an implement of learning of extreme value. I do not think its value can be exaggerated, because it gives you the means of training the young in attention and accuracy, which are the two things in which all mankind are more deficient than in any other mental quality whatsoever....You cannot begin this habit too early, and I consider there is nothing of so great a value as drawing to secure these two desirable ends."[1]

It is preferable to perform the laboratory exercises before the student has read a text or discussed the subject in the classroom. Individual work is more profitable, although in some cases group work or teacher demonstrations must be resorted to.

A great deal of laboratory work in an elementary course is done on external anatomy yet here and there one or two dissections or study of material under the microscope should be included. Youngsters like to discover "<u>what is inside anything</u>" and it is better to let them look in once in a while.

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1. Thomas H. Huxley, Science and Education: Collected Essays, Vol. III (N.Y.: D.Appleton and Co., 1894), p. 183.

Taking notes and answering questions during the observations is of great educational value. Neatness, correct position, proportion of parts and full labels should be required in all drawings. If a student can shade or learn to shade, let him do it so far as it brings added pleasure, but do not use his ability as a criterion to judge those who cannot do such finished products.

Although most laboratory work is done in the class room, sometimes it can be conducted outdoors. Field trips may take the place of the regular laboratory periods. If your school is near the seashore, take your class to the beach and study living forms where they actually live. If it is near a mountain, go up with the students and study plants and animals at different heights. If possible, take your group to the zoo to do laboratory work there.

The student's laboratory equipment may be very simple and inexpensive. A notebook, drawing paper, a soft pencil No. 2, an eraser and a short ruler may be enough.

A certain plan has been followed in preparing the exercises of this manual. There is a short introduction to each which includes information about the topic to be studied. The parts of each exercise are: object, materials, procedure, observations and conclusions. A few illustrations have been included in connection with several exercises.

GENERAL BIOLOGICAL PRINCIPLES

Exercise 1

CHANGES OF MATTER AND ENERGY

Matter is anything that occupies space and has weight. One form may be changed into another by physical or chemical changes.

Energy is the ability to do work. Like matter one form of energy may be converted into another, and just like matter it is not lost in the process nor can it be created thereby.

Object: To study some forms of matter and energy.

Materials: Pieces of charcoal, a candle, test tubes, beakers, lamp or burner, piece of glass, matches.

Procedure: A. Heat slowly a small lump of charcoal in a dish. B. Burn another lump by lighting it directly. C. Boil some water and collect the steam in a cold beaker. D. Light a candle and place a piece of glass over the flame.

Observations: 1. Compare the results of heating the lump of charcoal slowly with those obtained by burning another. 2. What physical change was observed by boiling the water? 3. When the steam was collected? 4. What was formed on the piece of glass placed over a burning candle?

Conclusions: 1. What changes in the state of matter did you evidence in procedures A to D? 2. Which were physical changes?

3. Which were chemical? 4. Describe the energy transformations in candle burning.

Exercise 2.

Diffusion, Osmosis and Filtration

Diffusion, osmosis and filtration are important processes since it is by them that materials move in or out of cells in living organisms.

Diffusion is the movement of molecules from regions of high concentration to regions of lower concentration.

Osmosis is diffusion through a semipermeable membrane.

Filtration is the movement of materials through cells due to differences in mechanical pressure on the two sides of the cell involved.

Object: To study diffusion, osmosis and filtration.

Materials: Beakers, copper sulfate crystal, egg, glass tubing, bag of fine cloth, starch.

Procedure:[1] A. Drop a crystal of copper sulfate in a glass beaker filled with water and let it stand without stirring for an hour or so. B. Dissolve the shell of an egg on both ends by using hydrochloric acid. Let the blunt end stand over the surface of water in a small beaker. Carefully set a piece of glass tubing on the exposed membrane at the pointed end of the egg and seal it with wax. Hold the tubing with a

1. This experiment may be performed as a demonstration by the teacher rather than by each individual student.

clamp and leave the apparatus overnight. C. Place a cooked starch solution in a bag of fine cloth. Immerse it in water and squeeze the bag slowly.

Observations: 1. Describe the intensity of the color at different points in the water having the copper sulfate crystal, after standing an hour and the next day. 2. What was the result of procedure B? What happened as you performed part C?

Conclusions: 1. What is the essential difference between diffusion and osmosis? 2. Between osmosis and filtration?

Exercise 3.

The Microscope

The microscope is an expensive and delicate instrument, essentially consisting of two sets of lenses which work together to magnify the size of objects so small that they can not be studied with the unaided eye.

1. The base is a horseshoe shaped piece on which the microscope rests.

2. The mirror is above the base, and is used to focus light.

3. The stage is large square pierced by a small hole, and serves to hold the object to be examined. Two clips are attached to the stage to hold the slide. Below the stage is the diaphragm to regulate the size of the opening and hence the amount of light that passes up.

4. The arm - arises from the base and is the part by which you should grasp the instrument always.

5. The body tube is at the top of the pillar, it bears the lenses which are:

6. The objectives are two lenses mounted on a revolving nosepiece located at the lower end of the body tube. The shorter of the objectives is the low power, the longer is the high power. In turning the nosepiece a small "click" lets you know that an objective is in position. When the microscope is not in use, the low power objective should be in position beneath the body tube.

7. The eyepiece is inserted in the upper end of the body tube. It is the ocular lens.

8. The coarse (large) and fine adjustment screws--on the sides near the top of the support of the body tube. They serve to raise or lower the body tube.

Mounting material on a slide: Clean the slide and cover glass to be used with lens paper. Place a drop of water in the center of the slide and into it place a very small piece of the material to be examined. Cover with the cover glass. Remove any excess of water present with lens or blotting paper.

How to use the microscope: Clean the eyepiece, objectives and mirror with lens paper. Always begin work with the low power objective. Adjust the mirror while looking through the eyepiece until you find a brilliant circular field. Clip in place upon the stage the slide you have prepared. Looking from the side, not through the ocular, lower the body tube by the coarse adjustment until the objective is very close to the slide but does not touch it. Now look through the eyepiece

and raise the body tube by the coarse adjustment until the object comes to focus. If you want to use the high power, focus the object under low power first. Then carefully turn the high power objective on, being careful not to bring it in contact with the slide. A very slight movement of the adjustment screw, coarse or fine, should bring the object into view.

Object: To learn how to use the compound microscope.[1]

Materials: Microscope, glass slides and cover glasses, small printed letters, bit of butterfly wing, medicine dropper.

Procedure: A. Examine a small printed letter under low and high power. Move the slide to the left, to the right, upwards and downwards. B. Examine a slide with a bit of housefly wing under the low and high powers of the microscope.

Observations: 1. Describe the image of the letter under low power, under high power. 2. What happened when the slide was moved to the right? to the left? Upwards? Downwards? 3. Describe the housefly wing under low power and under high power.

Sketch: 1. Image of a letter under low power. 2. Bit of housefly wing under high power.

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1. To prevent any damage, the teacher should explain briefly the parts of the microscope and its correct use before the students handle this instrument.

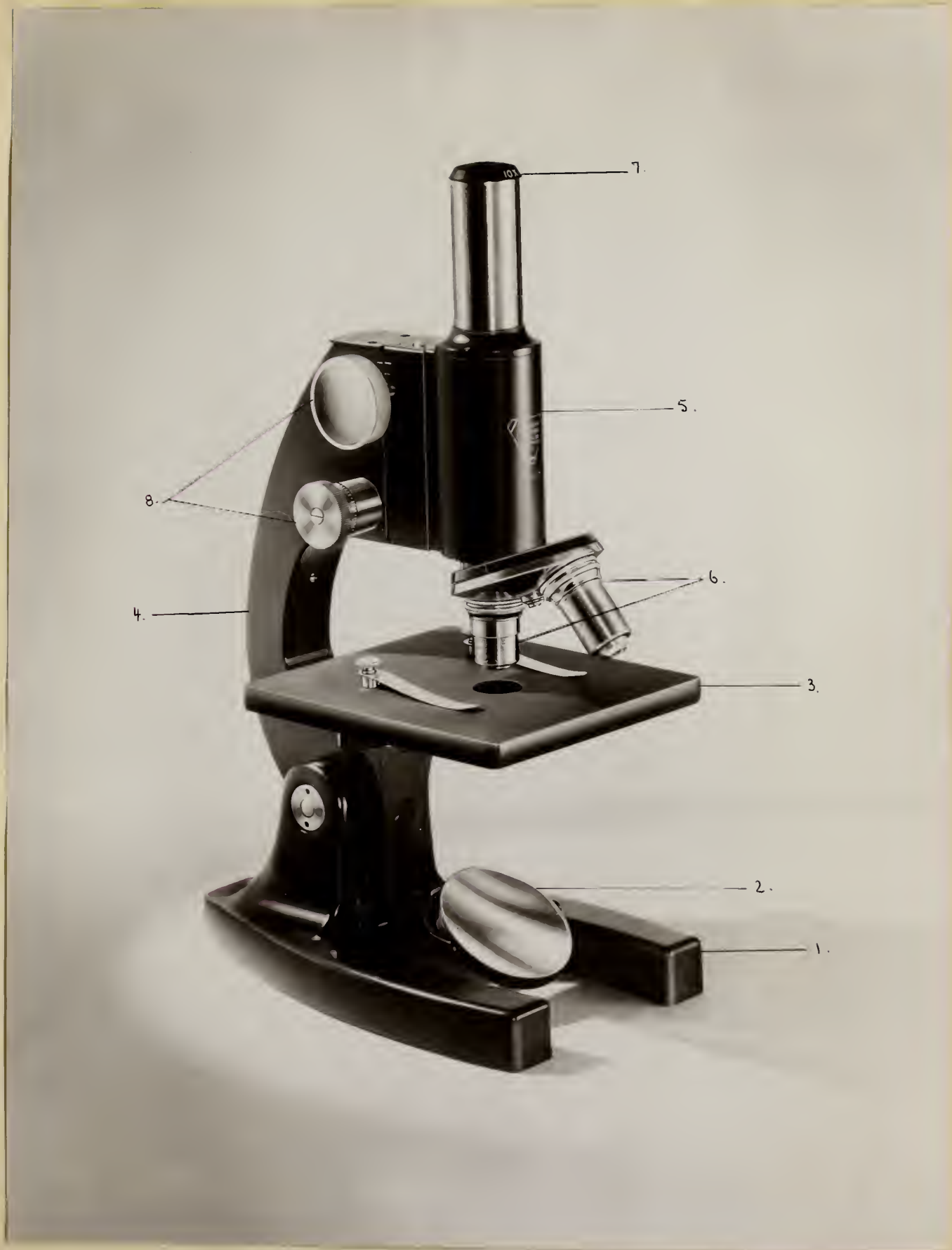


Fig. 1. The Microscope.

Exercise 4

The Cell

A cell is the unit of living structure as well as the unit of physiological functions.

Plant and animal cells are very similar, but plant cells have a cellulose cell wall while animal cells are generally surrounded by a thin membrane.

The protoplasm or living part of a cell is divided into a more or less round dense portion or nucleus and the more watery cytoplasm around the nucleus.

Object: To study the parts of plant and animal cells.

Materials: Lily leaf, flowers of Commelina (cohitre), scrapings of the inside of the human cheek, iodine solution, tooth picks.

Procedure: A. Examine a bit of the lower epidermis of a lily leaf placed on a drop of iodine solution on a slide. B. Examine the cells from stamen hairs of Commelina. C. With a tooth pick gently scrape the inside of your cheek. Mount the material and observe under reduced illumination.

Observations: 1. Describe the shape and contents of the clear cells in the epidermis of the lily leaf. 2. What do you see in addition in the smaller, bean-shaped cells? 3. What occurs in the protoplasm of the cells of the stamen hairs observed? 4. What is the shape of the cells from the scrapings of the cheek? 5. Compare with those in the epidermis of the lily leaf.

Conclusions: 1. What parts are present in all living cells? 2. What are some differences between plant and animal cells? 3. What is protoplasmic streaming?

Sketch: 1. Bean-shaped cell from epidermis of lily leaf. 2. Single cell from stamen hair of Commelina and indicate with arrows the direction of protoplasmic streaming. 3. Two or three cells from the lining of the human cheek.

Exercise 5.

Tissues and Organs.

A group of similar cells is a tissue. A group of different tissues is an organ.

Object: To study the different tissues making a plant organ. To study some animal tissues.

Materials: Leaves of Ficus (arbol de goma), toad, beef suet.

Procedure: A. Cut a very thin cross-section of a rubber tree leaf and examine under low power. B. Examine a drop of blood from a freshly killed toad. Mount and examine a thin slice of beef suet under low power. Mount a very thin bit of muscle from a toad's leg.

Observations: 1. Compare the shape and contents of cells on the upper surface of the leaf and those below them. 2. What is then the difference in function between them? 3. Compare the shape and position in relation to one another of the cells

nearer to the upper epidermis and those near the lower. 4. How do you account for the differences? 5. Describe the cells in the toad's blood. 6. What is found between the cells in blood tissue? 7. Describe the fat cells in beef suet. 8. What is the shape of the muscle cells in a toad's leg? 9. What are the cross-lines?

Conclusions: 1. What is typical of all cells forming a tissue? 2. Why is a leaf called an organ?

Sketch: 1. Palisade cells from Ficus leaf. 2. Spongy cells from Ficus leaf. 3. Few red corpuscles and a white corpuscle of toad's blood. 4. A few fat cells from beef suet. 5. Bit of muscle tissue from toad's leg.

Exercise 6.

Mitosis

Mitosis or indirect cell division consists of a series of complicated changes in the nucleus of a cell when it divides to produce two daughter cells. It is the basis of growth of an individual, plant or animal. For the sake of simplicity it may be divided into six stages.

1. The resting cell stage is a cell with a large more or less spherical nucleus in which the chromatin (substance of the nucleus) is in a granular form. Suppose it has x number of chromosomes.

2. The spireme stage. The chromatin has taken the form of a long looped thread.

3. The chromosome stage. The spireme splits lengthwise and then crosswise into finger like pieces called chromosomes. The cell has 2x chromosomes.

4. The equatorial plate stage. The chromosomes are arranged in the middle of the cell. They are in pairs due to the longitudinal splitting.

5. The polar chromosome stage. One half of each pair of chromosomes travel to opposite poles by being pulled by special elastic cytoplasmic threads. A new cell wall begins to be formed at the equator.

6. The 2 daughter-cell stage. The group of chromosomes at each pole is reorganized into the nucleus of each daughter cell and the cell wall at the equator is complete. Each of the 2 cells had x number of chromosomes.

Object: To study mitosis in plant cells.

Materials: Stained slides of onion root tips.

Procedure: Examine the growing point of the onion root tip and try to locate the stages described above.

Observations: 1. Trace the changes if any suffered by: A. The nuclear membrane. B. the chromatin. C. The cytoplasm. D. the cell wall, in the process of mitosis.

Conclusions: 1. What mechanism keeps a constant number of chromosomes in a cell when it undergoes mitosis? 2. What is the only difference between a resting cell and a daughter

cell? 3. How can it get to be just like the mother cell?

Sketch: 1. Diagram of six stages of mitosis.

Exercise 7.

Growth and Development of an Organism.

Living organisms are similar in that all begin by being a single cell. The multiplication of this cell gives rise to two cells, then four and so on and this increase in the number of cells is termed growth. Cells not only multiply, but they differentiate as well. They assume different structure and function to give rise to the tissues, organs and systems which make the sum total of an individual. The further development of an organism after birth is termed metamorphosis.

Object: To study the early development of an organism and a typical metamorphosis.

Materials: Early stages in the development of a starfish from stained slides. Stages in the development of a toad in an aquarium.

Procedure: Examine the above mentioned slides under the microscope. Notice the changes undergone from the newly hatched tadpole to the adult frog.

Observations: 1. What does the one cell stage represent? 2. By what process are the 2-4-16-32 cell stages formed? 3. How do the cells of the two-cell stage compare in size

with the one-cell stage? 4. Why? 5. Why is the number of cells in successive stages always a multiple of two? 6. What is the appearance of the organism after the 64-cell stage? 7. What cavity is formed by the inpushing of one side of this structure? 8. Compare the newly hatched tadpole and the next stage. 9. Which legs appear first? 10. What other changes must take place before the toad can leap out of the water?

Conclusions: 1. By what process can individuals increase in size? 2. What is the difference between the general term development and metamorphosis?

Sketch: 1. 2-4-8 cell stages in development of a starfish. 2. 3 successive stages in the metamorphosis of a toad.

PART II

Exercise 8.

Classification and Nomenclature of Plants and Animals.

Biology, being the science of living things, comprises a very wide field. Because of the very large number of living species, biologists find it necessary to group together those forms which resemble one another in one or several respects.

Organisms belong to either of two main divisions called kingdoms, the plant or the animal kingdom. These are subdivided into:

Phyla

Classes

Orders

Families

Genera

Species

Each plant or animal has two names, the first or name of the Genus is written with a capital letter, the second or specific name generally with a small letter. This system known as the binomial (two-names) nomenclature was devised by Linnaeus, a Swedish scientist. The language used in scientific naming is Latin.

A field trip would be suitable for working a little with classification. Students may be taken out to collect leaves, flowers, grasses, seeds or even insects. They should bring as many specimens as possible into the laboratory. These

may be grouped according to similarities and the teacher should guide them in putting similar things together. They may get down to a few orders and even families of plants and animals in this way.

PART III

Exercise 9.

Plant Biology

The Seed Plants

Maize, A Typical Plant.

Before starting the study of plant organs in more detail it is practical to present a plant as a whole so as to gain an idea of the relative position and function of the different parts.

A corn plant bearing tassel and young fruits is excellent for this purpose.

Object: To study a seed plant in general.

Materials: Corn plants in different stages of growth including mature specimens with tassels and ears.

Procedure: Examine the location of parts and the time when the different organs appear.

Observations: 1. What is the first organ formed in the corn seedling? 2. What is the main function of this part? 3. Of the stem? 4. What is the position of the leaves in relation to each other? 5. What is the importance of this? 6. What kind of flowers are found in the tassel? 7. In the ear? 8. What advantage is there in this position? 9. When do the leaves dry out? 10. Why?

Conclusions:

1. List the main organs of the seed plant beginning at the root, the position and main function of each in a tabular form:

Organ	Position	Function

Sketch: 1. Diagram of mature corn plant.

Exercise 10.

Organs of a Seed Plant

The Root

A Study of Root Hairs

The main function of a root is the absorption of water and mineral salts in solution from the soil. These are to be used with CO_2 in food manufacture by the process of photosynthesis that takes place in green plant tissues. To carry on this absorption, the epidermal surface of a root in some plants is increased in the region of the root tip, known as the root hair zone. A root hair is a very thin outgrowth of an epidermal cell.

Object: To study the formation and position of root hairs.

Materials: Radish seedlings, blotting paper.

Procedure: Germinate some radish seedlings between wet blotting papers. Examine some under low power. Make a series of marks with India ink. Examine three days later.

Observations: 1. Where are the longest root hairs? 2. Are there root hairs at the tip of the root? 3. Where has elongation taken place after three days? 4. Describe a root hair as seen under low power.

Conclusions: 1. How does the root hair zone change when a root elongates? 2. Why? 3. Why are they found above the zone of growth? 4. Why are they needed for absorption?

Sketch: 1. Sketch a root tip of a radish seedling.
2. Root hair under low power.

Exercise 11.

Secondary Functions of Roots.

Besides absorbing, roots assume other important functions in a plant. They serve to anchor the plant, to store food, manufacture food when green, for extra support, for reproduction and for aeration in many instances.

Object: To study specialized roots.

Materials: Roots of sweet potato, Ficus (arbol de goma), carrot, mangrove, Jussiaea[1], and epiphytic orchid.

1. Jussiaea repens is known as Yerba de clavo acuatica in Puerto Rico. It may be collected and kept a few days in the aquarium.

Observations: 1. What is the function of the long roots growing down from the rubber tree branches? 2. Compare their structure with that of the soil roots. 3. What happens in the carrot after adding iodine solution? 4. Explain. 5. Describe the cross section of the mangrove or Jussiaea root. 6. Explain. 7. What resulted from letting pieces of sweet potato stand in water for a few days? 8. What is the appearance of the roots of the epiphytic orchid studied? 9. Explain.

Conclusions: Summarize the specialized function of roots giving an example of each.

Sketch: 1. Cross section of carrot. 2. Cutting from sweet potato root. 3. Cross section of either mangrove or Jussiaea root.

Exercise 12.

Internal Anatomy of a Root.

A cross-section shows a root to be made up of three definite concentric layers. The outermost or epidermis is that provided with root hairs. Next to it lies the cortex, which is mainly a food storing region. In the center of the root is the vascular or conductive tissue known as the central cylinder. The outermost layer of this central region is the place of origin of secondary roots.

The conducting elements in a plant are: the xylem to carry water and dissolved substances, and the phloem to transport manufactured food. The xylem in the central cylinder of a root radiates from the center like the spokes of

a wheel. Between these xylem rays are the groups of phloem cells.

Object: To study the internal anatomy of some roots.

Materials: Roots of carrot and stained slides of cross sections of either Mungo bean roots or Commelina roots.

Procedure: Examine cross sections of roots of carrot, both cross and longitudinal cuts. Examine stained slides of cross sections of either young Mungo bean roots or Commelina roots.

Observations: 1. In what regions of the carrot root is food stored? 2. How can you prove it? 3. Compare the width of each of the three regions in the cross-section. 4. How far does each extend in the longitudinal section? 5. What is the difference between the cell walls in xylem and phloem? 6. Explain. 7. With what are each of these tissues going to connect above the root? 8. Which of the two is in contact with the cortex in the young root? 9. Why? 10. What is the condition in the older roots? 11. Why?

Conclusions: 1. How does the origin of a secondary root compare with that of a leaf or branch? 2. Trace the passage of water and solutes from the soil to the base of the stem.

Sketch: 1. Longitudinal section of carrot root (through secondary root.) 2. Central cylinder of root of either the Mungo bean or Commelina.

Exercise 13.

The Stem

Functions of the Stem

The principal function of the stem is to support leaves and reproductive organs so that they can carry on their various functions. In so doing it also transports raw materials and food to and from these parts.

Incidentally a stem may manufacture and store food, protect the plant, and even reproduce it. Others provide unusual methods of support.

Object: To study some of the functions of the stem.

Materials: Stems of: Ipomea (bejuco de puerco), Antigonon (bellisima), Muehlenbeckia (yerba de pelo), or Euphorbia tirucalli, Taro (Yautia), ginger, branch of lime.

Procedure: Examine the above mentioned stems and notice the form of each.

Observations: 1. How does the stem of Ipomea grow up? 2. Why? 3. What are the thin coiled structures in the branches of Antigonon? 4. How can they be used to the best advantage? 5. How can you tell the special function of the stems of Muehlenbeckia and Euphorbia? 6. Of taro? 7. What are the lines in the ginger stem? 8. What do you expect to be formed here? 9. What special features do you see around the stem of lime? 10. What part of the plant do they

represent?

Conclusions: List all the functions of stems studied above with the example of each.

Sketch: 1. Bit of stems of:

a. Ipomea

b. Antigonon

c. Muehlenbeckia (or Euphorbia)

d. Ginger

e. Lime

Exercise 14.

A typical Monocotyledon Stem--Corn

A monocotyledon plant may be told from a dicotyledon by some external features. Leaves of most monocotyledons have parallel veins while those of dicotyledons have a netted venation. Nodes and internodes are more clearly marked in monocotyledons than in dicotyledons. Dicotyledons are wider in diameter for their length and monocotyledons are very long in relation to their cross-section. Monocot flowers have their parts in threes or sixes, dicots usually in fours or fives or multiples of these.

Internally, the main differences between both are: Fibrovascular bundles are scattered in the pith in a monocotyledon they are arranged in the form of a circle in dicotyledons. There is a layer of cambium, cells that divide between xylem and phloem in a dicotyledon. Monocotyledons have no cambium, therefore no secondary thickening.

Object: To study the distinguishing features of a monocotyledon stem.

Materials: Adult corn plants. Cross sections of corn stem.

Procedure: Examine the external characteristics of the corn such as leaf-venation, comparative length and width; number of floral parts in each row. Examine the cross section of the stem under low and high powers.

Observations: 1. How are veins placed in a corn leaf? 2. What is the nature of the rind? 3. Why? 4. Where are the strongest points of the stem? 5. Stamens? 6. Where are the bundles most crowded? 7. Where are the largest bundles? 8. What is the position of the xylem? 9. Of the phloem? 10. What are the bigger, clear cells between the bundles? 11. What is the size of the cortex as compared with the central cylinder?

Conclusions: If you are given a certain plant, how would you tell if it is a monocotyledon by looking at it externally? What would you do if you are not sure?

Sketch: 1. Diagram of a radial section of a corn stem.

Exercise 15.

A typical Dicotyledon Stem. The castor-oil plant, Ricinus communis.

The chief differences between monocotyledons and dicotyledons were pointed out in the previous exercise.

Object: To study the main characteristics of a dicotyledon stem.

Materials: Branches of castor oil plant having leaves and flowers. Cross sections of the stem.

Procedure: Examine the external features of the branch as done on corn. Study the section of the stem under low and high powers.

Observations: What is the venation of the leaves? 2. How does the general texture of the stem compare with that of corn. 3. How many petals in the flower? 4. How many stamens? 5. What is the arrangement of the bundles? 6. What are the thick-walled innermost cells? 7. What are the brick-shaped cells outside of these? 8. Which are those resembling a net outermost to these? 9. What are the cells between the bundles?

Conclusions: The teacher may have several pieces of stems and mounted cross-sections for the students to classify as monocotyledons or dicotyledons. Summarize external and internal differences between a monocotyledon and a dicotyledon plant.

Sketch: 1. Diagram of a cross section of stem of castor oil plant.

Exercise 16.

The Leaf

The Parts of a Leaf

The leaves are one of the most important organs of a plant because within them most of the food of the plant is manufactured.

A typical leaf consists of a stalk or petiole and a broad, flat green surface or blade. Where the leaf joins the stem there may be one or two outgrowths, the stipules. Throughout the blade one can see the veins which serve for conduction and as a framework for the other tissues. There may be one or several main veins called midribs. The part of the blade nearer the stem is the base, that farthest from it, the apex. The edge or outline is the margin.

Object: To study the parts of some typical leaves.

Materials: Leaves of: Ficus, (arbol de goma), before and after they unfold; mango leaves, Hibiscus leaves.

Procedure: Study the parts of each of the above mentioned leaves.

Observations: 1. What covers the rubber tree leaves before they unfold? 2. What becomes of these? 3. How are these structures in the Hibiscus leaf? 4. Describe the margin, apex and base of each leaf studied. 5. Where does the midrib originate? 6. Where do the smaller veins originate? 7. Where do they end? 8. What are the functions of the petiole?

Conclusions: 1. Why is the blade relatively thin and expanded? 2. How do you account for the difference in texture between its upper and lower surfaces?

Sketch: 1. View of either the rubber tree or the Hibiscus leaf.

Exercise 17.

Leaf Venation.

The leaves of flowering plants show two very distinct types of venation or arrangement of the veins. In one type the veins are parallel, in the other they are netted. Parallel veins may be parallel to each other, and at the same time parallel to the midrib; or they may be parallel to each other but not to the midrib. Netted veins may originate from a central midrib and form a pinnately netted-veined leaf, or there may be several midribs arising from a common point to form a palmately netted-veined blade.

Object: To study the different types of leaf venation.

Materials: Leaves of grasses, banana, papaya, eggplant, mango, canna, sugar cane, castor oil plant, orange.

Procedure: Study the disposition of veins in the above mentioned leaves.

Observations and Conclusions:

Fill in the chart.

Leaf	General type of venation	Kind of parallel or netted venation	Monocotyledon or dicotyledon

Sketch: 1. Diagram of the four different types of venation.

Exercise 18.

Arrangement of Leaves

Leaves occur on the stem in a number of different arrangements. They may be attached opposite each other at the same node and then are said to be opposite leaves. If only one leaf occurs at a node and they form a spiral around the stem these are called alternate leaves. When three or more leaves are attached to the same node they are designated as whorled.

Object: To study the different types of leaf arrangement.

Materials: Branches with leaves of guava, Cestrum nocturnum (dama de noche), Allamanda, Plumiera rubra (alheli), Eucalyptus, Hibiscus.

Procedure: Study the position of these leaves on the stem.

Observations and Conclusions: 1. What is the relation between a leaf and the one above or below it? 2. What is the importance of this to photosynthesis? 3. What type of arrangement is shown by each of the branches studied?

Sketch: 1. Diagram of each of the three types of leaf arrangement.

Exercise 19.

Compound Leaves

The blade of a leaf may be made up of a single piece in which case it is called simple, while if it is divided to the

midrib it is compound. Compound leaves are either pinnate when the leaflets arise from a main axis or palmate if the leaflets originate from a common point. A compound leaf where the leaflets themselves are compound is termed bi-pinnate.

Object: To study different types of compound leaves.

Materials: Leaves of Spondias (jobo), Crotalaria, Leucaena (Acacia), flame tree (flamboyan), Quercus Thomsonii (roble), rose.

Procedure: Study the subdivisions of the blade of each of the leaves called for.

Observations and Conclusions: 1. Which plants seem to have their leaves more subdivided? 2. Explain. 3. Tabulate the leaves studied today as follows:

Leaf	Venation	Arrangement	Kind of compound leaf

Sketch: 1. Diagram of each of the types of compound leaves.[1]

Exercise 20.

Modified Leaves

Besides manufacturing food, leaves may assume other

1. Students may now be taken to a field trip and allowed to review the facts studied in all exercises on leaves. They can do so by studying them around the field as they come in contact with them.

specialized functions. They may serve to support the plant when the stem is not able to support all the aerial parts. They may absorb water thus assuming a root function; attract insects which is a floral function, store food or even reproduce the plant. Many times they protect the plant.

Object: To study the special functions of some leaves.

Materials: Leaves of: banana including the whole base, water hyacinth plant, a bromeliad, flowers of Bougainvillea (trinitaria), or Congea (lluvia de orquideas), leaves of Bryophyllum (bruja), an onion bulb, leaves of century plant (maguey).

Procedure: Examine the structure of each of the leaves brought in. Hang the leaves of Bryophyllum on the wall two weeks before doing this exercise and observe them frequently.

Observations: 1. What is the real stem of the banana? 2. How are the leaf bases modified? 3. What is the shape of the petiole of the water hyacinth leaf? 4. Explain. 5. What is the position of bromeliad leaves in relation to each other? 6. What is the advantage of this? 7. What do the leaves contain on their inner surface? 8. What is their use? 9. What are the colored structures around either Bougainvillea or Congea flowers? 10. Why is this so? 11. What is formed at the notches in the margin of life plant leaves? 12. What are the thickened fleshy structures in an onion bulb?

13. How do the leaves of the century plant protect it?

Conclusions: List seven secondary functions of a leaf and give an example of each.

Sketch: 1. Leaf of water hyacinth. 2. Leaf of Bryophyllum. 3. Flowers of Bougainvillea.

Exercise 21.

Photosynthesis:

Photosynthesis is a very complex process. The raw materials are water and solutions absorbed by the plant roots and carbon dioxide, which diffuses from the atmosphere through the stomata of the leaves. The process must take place in the presence of chlorophyll, or green coloring matter, in plant tissues, and the energy used up is obtained from the sunlight.

Object: To study some factors involved in photosynthesis.

Materials: Variegated leaves of Ixora (nevado), submerged aquarium plants, vigorous geranium plant, funnel, test tube, clamp, 40% alcohol, iodine solution.

Procedure:[1] A. Soften the leaves of Ixora by boiling in hot water. Now boil them in 40% alcohol to remove the green substance. Test with iodine solution. B. Cover a part of a geranium leaf with carbon paper on both surfaces. After

1. This experiment may be performed as a class demonstration.

doing so let it stand in the sunlight for a week before this exercise. Remove the leaf and follow procedure A. C. Cover a submerged water plant with a funnel and place a test tube filled with water over the end of the funnel. Clamp it and let it stay near the sunlight for two weeks before the exercise is done. Now insert a glowing splinter into the test tube.

Observations: 1. Where is starch present in the tested Ixora leaves? 2. Where did you get a positive test in the geranium leaf? 3. What happened when you inserted the splinter into the test tube in part C.

Conclusions: 1. What is your conclusion to procedures A, B & C?

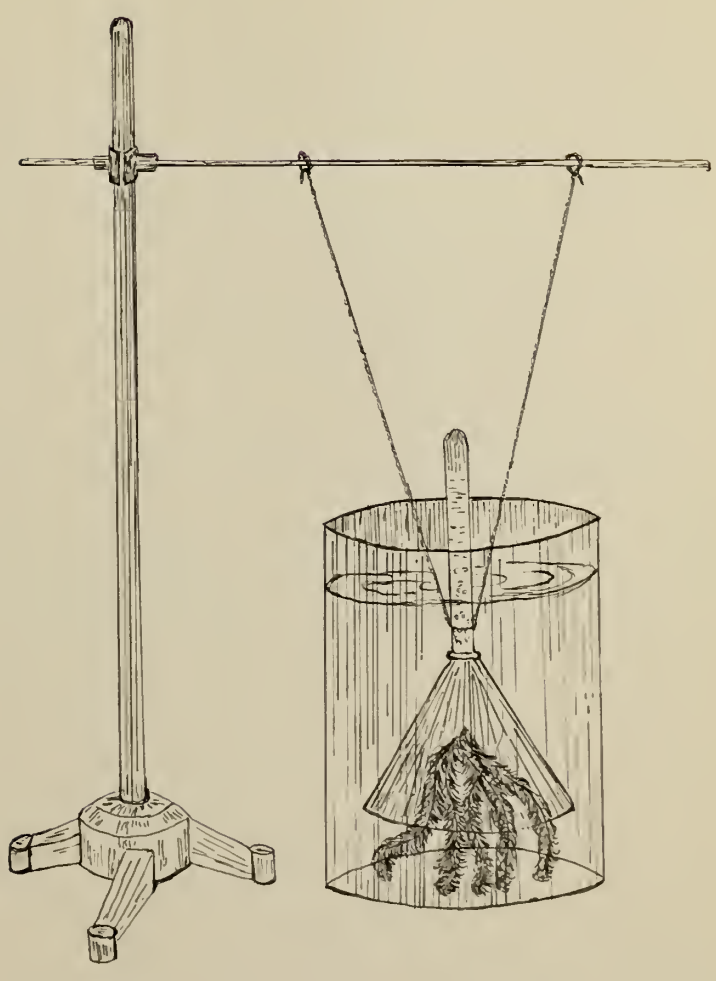


Fig. 2. Photosynthesis

Brown, 1935, pg. 53.

Exercise 22.

Respiration in Plants.

Respiration is the oxidation of food with the liberation of energy. It is carried on by all living cells. The ultimate products of the breaking down of dextrose are carbon dioxide and water. If compared with photosynthesis it will be found to be the reverse. Oxygen for respiration is obtained from the air through the stomata and from photosynthesis under ordinary conditions in bright light. When leaves are in the dark they are not liberating oxygen.

Object: To study respiration in leaves and seeds.

Materials: Few small green leaves, test tube, Petri dish, potassium hydroxide solution, a vacuum flask, germinating bean seeds (these can be prepared in advance by keeping moist for twenty-four hours), small vial containing fifty percent potassium hydroxide, thermometer, cotton.

Procedure: A. Place a few small green leaves in the bottom of a test tube and hold them there by a small amount of cotton. Invert the test tube over a solution of potassium hydroxide in a shallow Petri dish. Let it stand for two days and mark the level of the water in the test tube several times. Make two preparations. Keep one in the light and one in the dark. B. Partially fill a vacuum jar with germinating bean seeds. Place a vial with potassium hydroxide in the

flask. Insert the thermometer through the mouth of the jar and put a plug of cotton in the mouth to allow air to enter the flask. Observe the temperature at different times for two days. Make a similar preparation with dead seeds.

Observations: 1. What was the result of procedure A?
2. Of procedure B?

Conclusions: 1. Why did you get a different result for each preparation in A? 2. How do you account for the differences if any in part B?

Note: This exercise may also be made as a demonstration since materials needed are too expensive to supply to individual students.

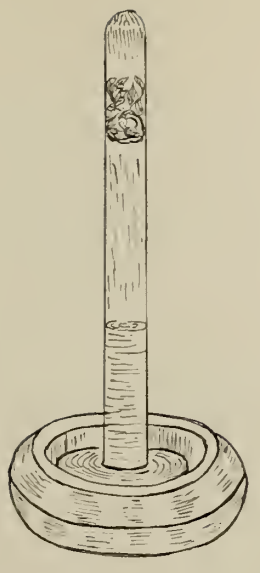


Fig 3. Respiration of Leaves.

Fig 4. Liberation of Heat in Respiration

Brown, 1935, pg. 78.

Exercise 23.

Transpiration.

Transpiration is the loss of water through the stomata; the water passes out in the form of vapor into the air.

Object: To study transpiration of water from leaves.

Materials: Bell jar, small potted plant, piece of wax paper, string.

Procedure: Cover the ground surface of the small potted plant and tie the paper around the pot with a string. Cover the plant with a bell glass whose walls are dry. Make a similar preparation using a dry branch instead of the plant. Let both stand overnight.

Observations: 1. What do you see on the inner walls of the bell jar? 2. Where does it come from? 3. What does the second preparation prove in relation to the origin of the droplets?

Conclusions: 1. What harm is there in keeping potted plants in a bedroom? 2. When is it that this may really do harm?

Note: This is another experiment to be performed as a single demonstration for the whole group.

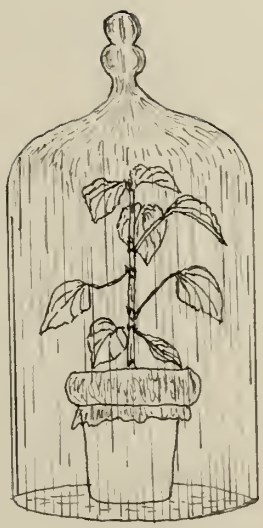


Fig 5. Transpiration in Leaves

Exercise 24.

A Study of Stomata.

Transpiration is regulated in leaves by several mechanisms the most important of which is perhaps the opening and closing of stomata.

Object: To study the structure of stomata and the mechanism that regulates their opening and closing.

Materials: Leaves of wandering jew (cohitre morado), lily, rubber tubing, glass Y tube, two elongated toy balloons, rubber bulb, adhesive tape.

Procedure: A. Examine the lower epidermis of wandering jew and lily leaves under the low and high powers of the microscope, first, when there is water on the slide, second, without water on the slide. B.[1] Place some adhesive tape on one side of each of the rubber balloons. Put them so that these two sides are in contact. Attach the Y tube and rubber tubing so that the balloons may be slightly inflated by the rubber bulb attached at the end of the tubing as shown by figure 6. Inflate the balloons slowly.

Observations: 1. Where is a stoma located? 2. How do the guard cells differ from the other epidermal cells? 3. How is a stoma when there is much water on the slide? 4. When there is little water? 5. How does the mechanical demonstration with the rubber balloons illustrates opening and closing

1. Procedure B may be done as a teacher demonstration.

of stomata?

Conclusions: 1. Why do you think that the guard cells have chloroplasts, while the rest of the epidermal cells lack them? 2. What, then, is the essential factor that regulates the size of a stoma?

Sketch: 1. Surface view of a stoma of wandering jew (or lily) leaf.

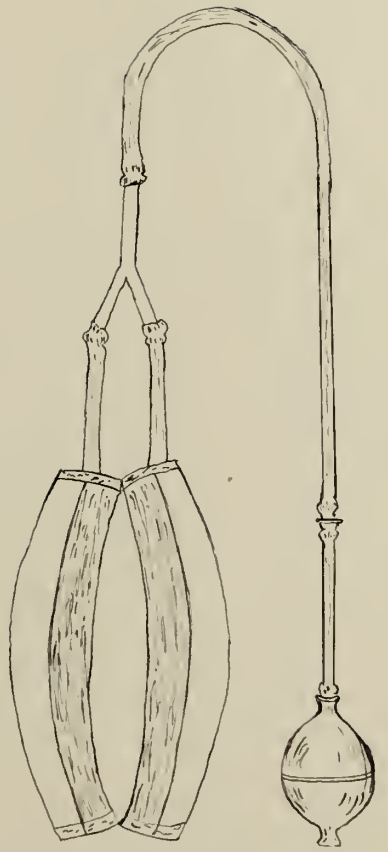


Fig. 6. Apparatus to Demonstrate Opening and Closing of a Stoma

Brown, 1935, pg 99.

Exercise 25.

The Flower

A Study of Floral Parts

A flower is a reproductive structure the function of which is to produce seeds. A typical flower has four different sets of parts. Outermost are the sepals and next within are the petals, then the stamens and innermost is the pistil or pistils. Each of these has a special function to perform.

Object: To study the parts of a typical flower, and the function of each part.

Materials: Flowers of Hibiscus and Solanum torvum (berenjena cimarrona).

Procedure: Study the different floral parts, the relative position of each and their function. Cut a section of the base of the pistil and examine with a hand lens.

Observations: 1. What is the color of the sepals? 2. What is their position in the bud? 3. Compare the size and color of petals with those of the sepals? 4. Explain. 5. What are the parts of the stamen? 6. What do you find at the upper part of it? 7. How many parts in a pistil? 8. What is the texture of the stigma? 9. What do you see in the cross-section of the ovary? 10. What are these going to be?

Conclusions: 1. List the floral parts and the function of each.

Sketch: 1. Flower of Hibiscus or Solanum (one sepal and one petal removed).

Exercise 26.

Classification of Flowers

The sepals and petals of the flower are accessory parts. The pistil, or female organ, and the stamen, or male organ, are the essential parts since they are the ones directly concerned with the production of seeds. A flower having both essential organs is said to be perfect; one lacking one of these is imperfect.

Flowers having all the accessory parts plus all the essential organs is a complete flower. One where any of the four sets of floral parts is missing is called an incomplete flower.

Some flowers are regular when all the members of each set of organs are alike, while others are irregular if this is not the case.

Object: To study the different types of flowers.

Materials: Flowers of: pawpaw, grapefruit or lemon, rose, raintree(Acacia), Hibiscus, pumpkin, beans, Montezuma (maga), Crotalaria, Momordica (cundeamor).

Procedure: Study the parts and shape of parts in the different flowers brought in.

Observations and Conclusions: Tabulate the flowers studied as follows:

Flower	As to essential organs	As to floral parts	As to symmetry of parts

Sketch: Flowers of: 1. Pawpaw (or pumpkin) 2. Crotalaria (or beans).

Exercise 27.

Floral Diagrams and Formulas

Taxonomists find it very convenient to keep records of flowers by means of diagrams and formulas. They can include most of the characteristics of the flowers of each family in a very condensed form by working the diagram and formula of a typical flower of each family.

There is a floral symbol for each floral element:

Ca = Calyx.

Co = Corolla

S = Stamens

P = Pistils

The number of times an element occurs is expressed by an exponent. Thus Ca^5 means five sepals in a calyx. If all the elements are written on the same line the flower has a superior ovary = Ca Co S P. If the ovary is inferior = $\frac{\text{Ca Co S.}}{\text{P}}$

A circle around an exponent indicates the degree of union of parts, so:

Ca^5 = all sepals separate.

$Ca^{(5)}$ = all sepals united.

$Ca^{\underset{\frown}{5}}$ = all sepals half united.

If there is a very great number of any part the exponent becomes ∞ (infinite)

If an element is absent the exponent becomes 0.

If in a row, one element is different from the rest:

$Co^{4.1}$ means 4 petals alike, 1 unlike.

If stamens are united to the petals = $\frac{S}{Co}$.

If the stamens are united to each other by the filament = $S^{\underset{\frown}{5}}$. If by the anther = $S^{\overset{\frown}{5}}$. If by the anther and filament $S^{(5)}$.

After the formula has been derived, the diagram can be made from the formula by using a few simple rules. These are illustrated by Figure 7.

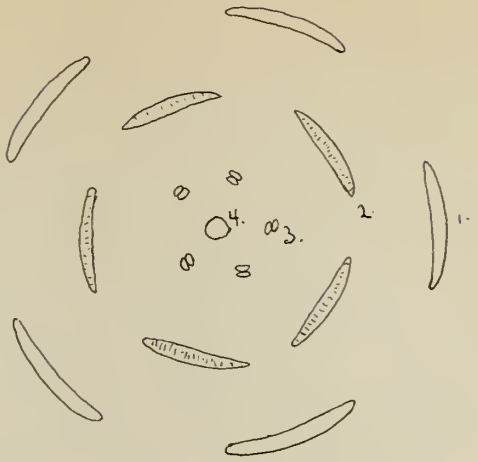
When an accessory part is absent in a flower, the corolla is the one considered absent.

Object: To make some floral diagrams and formulas.

Materials: Flowers of: Antigonon (bellisima), Hibiscus, Agati grandiflora (gallitos), Chalcas exotica (mirto).

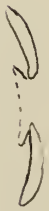
Procedure: Examine the flowers and work the formula for each, then make the diagram from each formula.

$Ca^5 Co^5 S^5 P^1$.



1. Sepals
2 Petals
3 Stamens
4. Pistil

Parts wholly united



Parts partly united

United by anthers.

United by filaments

United by both

Stamens

Stamens Attached to Petals

Alternately

Oppositely

Fig. 7. Floral Diagrams.

Exercise 28.

The Fruit

The Types of Fruits

The fruit is essentially a ripe ovary but sometimes it may include other floral parts connected with the ovary.

Fruits are said to be dry when there is no pulp, and fleshy when they contain pulp. Dry fruits, which open to discharge their seeds, are called dehiscent fruits; indehiscent fruits do not open.

Of the fleshy fruits, the most common types are the berries, which are many seeded with a relatively thin wall; the drupe, which generally contains a single seed enclosed in a stone; and compound fruits, which are derived from many flowers or many pistils growing together into an aggregate single fruit.

Object: To study some types of fruits.

Materials: Fruits of: Bixa (achiote), sensitive plant, (Mimosa pudica), Abrus (peronia), Spathodea (tulipan africano), guava, tomato; Artocarpus (breadfruit), pineapple, mango, cocoanut.

Procedure: Compare and contrast all the fruits called for above.

Observations: 1. Which are dry fruits in the group? 2. Which are dehiscent? 3. Indehiscent? 4. Contrast the guava and mango. 5. Contrast the tomato and the breadfruit.

6. The breadfruit and pineapple.

Conclusions: 1. List and classify completely each of the fruits studied.

Sketch: 1. Any dry dehiscent fruit. 2. Any dry indehiscent fruit. 3. Breadfruit (sectioned on one side). 4. Longitudinal section of guava.

Note: A field trip to collect wild fruits and classify them will be very useful at the end of this exercise.

Exercise 29.

The Seed

Parts of a Seed.

A seed is a ripe ovule. It consists of an embryo plant, stored food and one or two seed coats.

Object: To study the parts of some seeds.

Materials: Seeds of corn, bean, breadfruit.

Procedure: Soak some seeds of corn, lima bean and breadfruit in water for twenty-four hours. Study these and dry ones of the same kind. Examine the corn and bean embryo with a dissecting microscope.

Observations: 1. What is the difference between the outer and inner seed coats of the breadfruit seed? 2. How does this compare with the bean seed? 3. What is the largest

portion in the bean seed? 4. What does the scar on the side represent? 5. What is the small hole above it? 6. What is the use of this? 7. Describe the embryo as seen under the microscope. 8. Compare it to that of corn. 9. Why can't you see the seed coat in the corn grain?

Conclusions: 1. What becomes of each of the parts of the seed when it germinates? 2. What is the use of the seed coats? 3. Into what does each part of the embryo grow?

Sketch: 1. Open breadfruit seed showing coats and embryo. 2. Bean seed embryo.

Exercise 30.

Seed Dispersal.

Most seeds are provided with some means of dispersal. Without this most of them would fall under the parent plant and not on a favorable location for growth.

Seeds are dispersed by wind, water, animals or by an explosive mechanism of the fruit.

Object: To study the adaptations of some seeds for dispersal.

Materials: Seeds of Cenchropsis (abrojo), Bidens (beggar ticks), Querqus Thomsonii (roble), Spathrodea (tulipan africano), Vernonia (escobilla), Terminalia (almendro), Mucuna (mato), Impatiens balsamica (espuela de galan), Hyptis suaveolens (marubio), Aristolochia elegans (cachimbo).

Procedure:[1] Examine the adaptations of each of the above seeds and tabulate them.

Observations and Conclusions:

Seed	Special structure	Agent of dispersal

Sketch: Seeds of Cenchropsis, Spathodea, Vernonia, Mucuna, Impatiens.

Exercise 31.

Germination

Germination is the development of a seed containing an embryo into a young plant seedling. It is really a process of growth and it is influenced by several factors.

Object: To study the stages in the germination of a seed and the conditions affecting this process.

Materials: Bean seeds, sand boxes, wide-mouthed bottles, blotting paper, cotton.

Procedure: A. Prepare some wide-mouth bottles with a bit of

1. Students can go on a field trip to study dispersal of various seeds found.

cotton or blotting paper on the bottom and do as follows:

Bottle one 6 seeds on top of very wet cotton plug, uncovered bottle.

Bottle two 6 seeds on top of dry cotton plug, uncovered bottle.

Bottle three 6 seeds on top of very wet cotton plug, covered bottle.

Bottle four 6 seeds on top of very wet cotton plug, inside the refrigerator.

Bottle five 6 seeds on top of very wet cotton, uncovered kept in a warm corner. Observe these frequently for a week.
B. Plant some soaked bean seeds in a sand box. Make about five plantings allowing three days to elapse between one planting and the next. When the first grown seedlings are about one and one half inches high, pull seeds from the different plantings and observe the different stages in germination.

Observations: 1. Describe the results in each of the 5 bottles set up in procedure A. 2. What changes do you see from the first to the fifth stage in the germination of bean seeds.

Conclusions: 1. What are the conditions necessary for the germination of a seed? 2. Why is there an arch in the growing hypocotyl? 3. What becomes of the seed coats? 4. Why are the cotyledons called seed-leaves?

Sketch: 1. Five different stages in the germination of a bean seed.

Exercise 32.

The Seedless Plants

Algae.

The seedless plants are those that reproduce by spores or direct cell division. They are more primitive than flowering plants but not less important.

The Thallophytes compose the lowest group and include the algae and fungi.

Object: To study some algae.

Materials: Oscillatoria, either Spirogyra or Zygnema from pond scums, Sargassum.

Procedure: Study Oscillatoria and Spirogyra (Or Zygnema) under low and high power. Examine a piece of Sargassum and compare to the others.

Observations: 1. What is the shape of a colony of Oscillatoria? 2. Why has it been given that name? 3. What do you see inside the cells? 4. What is the color of Spirogyra (Zygnema). 5. What do you see inside the cell? 6. What are these colored bodies? 6. After adding a drop of iodine solution, what else do you see? 7. How can Sargassum stay afloat?

Conclusions: 1. From the observations list four distinguishing characteristics of blue-green, green and brown algae.

Sketch Oscillatoria, Spirogyra (or Zygnema), Sargassum.

Exercise 33.

Fungi

Fungi differ from algae essentially in that they lack chlorophyll. Since they can not manufacture their own food they get it either by living as parasites on living plants and animals, or saprophytically from dead plant or animal remains.

Object: To study some typical fungi.

Materials: Bread mold, yeast, wild mushrooms in different stages of development, sugar, piece of bread.

Procedure: Moisten a piece of bread and, after allowing it to stand in the air for ten minutes, put it in covered Petri dishes or finger bowls. Dissolve a yeast cake in a sugar solution and let it stand for forty-eight hours. Observe some wild mushrooms and examine the under surface of the cap under the microscope.

Observations: 1. Describe the colony of bread mold. 2. What do you see in the ball-shaped structures at the tip of the upright filaments? 3. Into what do these develop? 4. Why are some of them white while others are black? 5. Of what is a yeast plant composed? 6. What is the shape of the

colony? 7. What are the small protrusions at the sides? 8. How has the sugar solution changed in odor? 9. What is escaping from the solution? 10. Describe the cap of a mushroom. 11. What do you find between the gills? 12. When does the cap turn inside out?

Conclusions: 1. What type of fungus is each one studied in accordance to the food they use? 2. What is the reaction of yeast on sugar solution? 3. Why was it so easy to obtain a culture of bread mold? 4. What is the main difference between a spore and a seed?

Sketch: 1. Filaments of bread mold. 2. Yeast colony. 3. Gill of a mushroom.

Exercise 34.

Liverworts and Mosses.

Liverworts are found in the high moist places of the West Indies. They are not at all common to most students, but material may be collected for laboratory use from such places as El Yunque, and other highlands in Puerto Rico. The plant body is a green, flat, lobed structure attached to wet rocks, ground, and tree trunks by means of root-like structures called rhizoids.

Mosses are more familiar, although they are relatively small plants. They consist of an upright stem with small leaves.

Object: To study the general external anatomy of a liverwort and a moss.

Materials: Liverworts collected from the nearest mountain, and specimens of Polytrichum. Museum demonstration of Marchantia.

Procedure: Examine and compare the specimens of liverworts and mosses available.

Observations: 1. How does a liverwort differ from algae? 2. Why are these plants called hepaticas? 3. Contrast the liverwort and the moss. 4. What is the arrangement of the leaves?

Conclusions: From the above observations list what seem to you the characteristics that distinguish liverworts and mosses from algae and fungi.

Sketch: 1. Thallus of liverwort. 2. Moss plant.

Exercise 35.

Ferns.

Ferns are true land plants, though they live in moist places. They are more specialized than the rest of the seedless plants studied so far.

Object: To study the characteristics of ferns.

Materials: Fern plants having "fruit dots" or sori on the leaves. Cross-sections of fern stems.

Procedure: Observe the parts of a fern plant. Examine a fruit dot and a cross-section of the stem under the microscope.

Observations: 1. Compare the unfolding of leaves in ferns and in seed plants. 2. What makes up a sorus? 3. Compare the leaves of a fern with those of a moss. 4. Compare a vascular bundle with that of a seed plant. 5. What type of stem is typical of ferns?

Conclusions: 1. Why are ferns considered a higher group than liverworts and mosses?

Sketch: 1. Fern sorus under dissecting microscope. 2. Fibrovascular bundle of fern.

ANIMAL BIOLOGY

PROTOZOA

Exercise 36.

Ameba and Paramecium

Protozoa are the simplest of all animals. They are made up of a single cell which is capable of performing all the basic physiological processes necessary for life such as growth, respiration, excretion, metabolism and reproduction.

Object: To study the structure of the Ameba and compare it with a Paramecium.

Materials: Cultures of living Amebae and Paramecia are preferred to stained slides. Culture methods are included in the appendix. Compound microscope, pipettes or droppers. Stained slides may be observed also.

Procedure: Mount a drop of the ooze from the vessel containing Amebae and Paramecia and examine it under high and low powers.

Observations: 1. What is the shape of the body of the Ameba? 2. Why? 3. What is the use of these structures? 4. Compare with Paramecium. 5. What is the appearance of the protoplasm of the Ameba as seen under high power? 6. What is the clear spot near the periphery? 7. How does it work? 8. What is the large dark portion observed in the stained preparation? 9. How does the Paramecium move? 10. How does it feed? 11. What are the clear vesicles near the end of the body? 12. Watch the formation of one and describe it.

13. Describe the nuclei as observed in the stained slide.

Conclusions: 1. List the common characteristics in the Ameba and Paramecium. 2. In what respects do both animals differ?

Sketch: 1. Ameba 2. Paramecium (both from living culture).

Exercise 37.

The Malarial Parasite

Plasmodium, the malarial parasite, is a parasitic Protozoan whose life history requires two hosts, an Anopheles mosquito and a human being. The adult parasite lives in the red blood corpuscles of man.

Object: To study the adult Plasmodium.

Materials: Slides of Plasmodium may be easily obtained from hospital laboratories.

Procedure: Examine slides with blood samples infected with the malarial parasite. Secure or prepare a chart of the whole life history and study it during the rest of the laboratory period.

Observations: 1. Describe the adult Plasmodium. 2. What other Protozoan does it resemble? 3. What is the effect of the parasite on the blood? 4. How can so many blood cells become attacked.

Conclusions: 1. Trace the life history of the malarial parasite from one patient to another. 2. Describe the cycle of Plasmodium within a single human individual. 3. Which are the best methods of controlling malaria?

Sketch: 1. Make a diagram of the life history of malarial parasite.

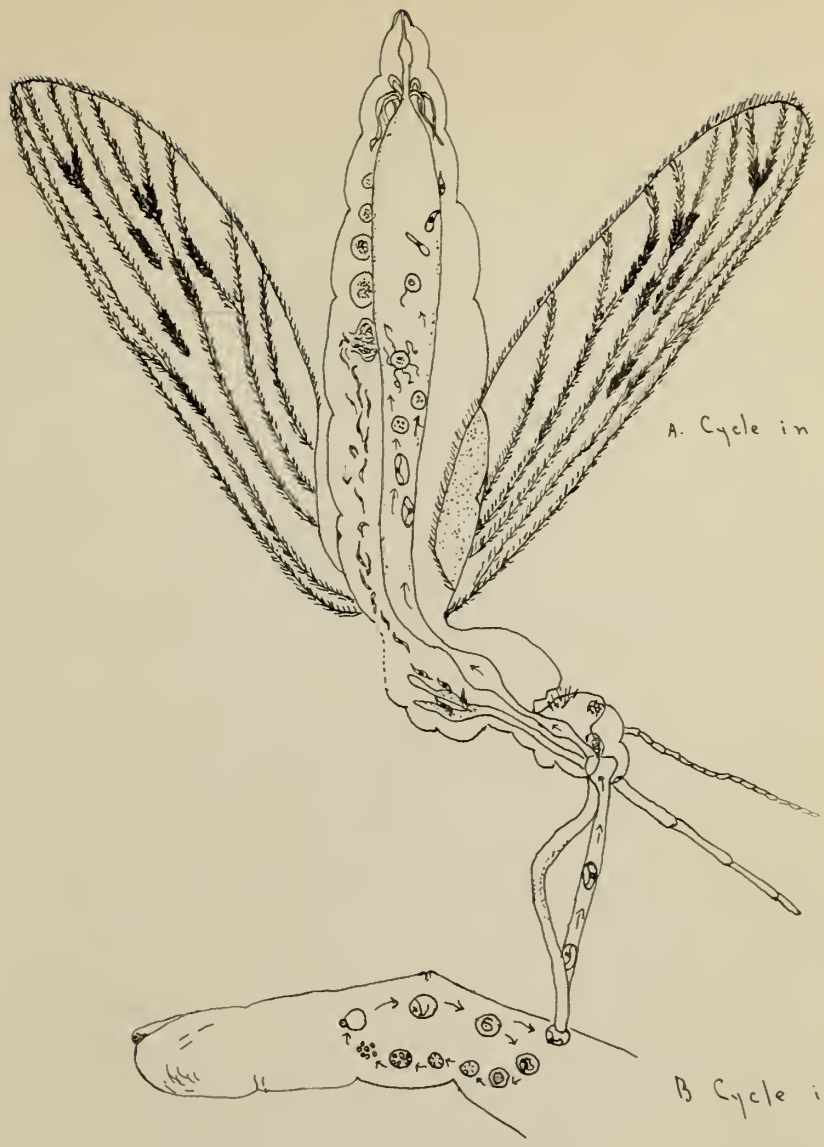


fig 8. Life History of Malarial Parasite.

Riley, 1915, pg. 193

fig. 9. Normal Position of Culex and Anopheles on a Wall

Riley, 1915, pg. 195.

Exercise 38.

Sponges

The skeletons of sponges are familiar to everybody since they are commonly used for bathing purposes. Few individuals realize that once they were colonies of living animals. Sponges are very primitive and live a sedentary life. When alive they are rather slimy and if observed with a hand lens the body is found to be perforated by numerous small openings, the pores. Each individual possesses one or more apertures for the outcoming of water, the oscula.

Object: To study the general structure of sponges.

Materials: Skeletons of sponges collected from the coast, slides of sections of Grantia, some specimens containing the "flesh".

Procedure: Examine specimens of sponges with and without the "flesh". Observe the sections of Grantia under low power.

Observations: 1. What do you find at both ends of a sponge? 2. At the sides? 3. What is the function of these? 4. What is the texture of the skeleton? 5. Describe the skeletal material observed in the sections of Grantia. 6. What occupies the central portion of the animal? 7. With what does this connect?

Conclusions: 1. Account for the strong skeleton of sponges. 2. Trace the course of a food particle in and out of a sponge. 3. Why do you think that sponges are animals and not plants?

Sketch: 1. Skeletal material of Grantia. 2. Bit of a colonial sponge (with the flesh).

Exercise 39.

Coelenterates

The Sea Anemone

Coelenterates are animals most of which live in the sea. They are the only living forms that possess stinging cells for offense and defense; these being the cause of many a painful experience of bathers along our coasts.

Object: To study the sea anemone.

Materials: Specimens of living sea anemones are easily obtained from our sea shores. They are found buried in the sand along tide lines, or attached to rocks close to the shore. They may be kept alive in sea water for several days and may be fed with firm fragments of fish, crab or beef.

Procedure: Observe the activity of a living specimen. Feed it. Observe a longitudinal and a cross section of the animal.

Observations: 1. What parts make up the body of the sea anemone? 2. What structures do you find on the crown?

3. What changes in shape occur in this animal? 4. When? 5. What happens to the crown of tentacles when the animal is disturbed? 6. Describe the activity of the animal when you feed it. 7. Where are the stinging cells most abundant? 8. Why? 9. How can the animal attach itself so firmly to the substratum? 10. What are the partitions seen in the cross section?

Conclusions: 1. What features distinguish the sea anemone from other animals studied? 2. What adapts the animal to the environment?

Sketch; Top view of living sea anemone.

Exercise 40.

The Corals

Corals are familiar to inhabitants of the tropics. Branching forms and ornamental pieces are easily recognized, but not everyone knows that the big whitish "stones" along the sea shores were once secreted by millions of coral polyps as well.

Object: To study the skeleton of certain corals.

Materials: As many different pieces of coral skeletons as might be collected. It is possible to keep some museum mounts of corallites with the animals attached.

Procedure: Observe corallites and coral polyps available.

Test some bits with hydrochloric acid.

Observations: 1. What do the small cups on the coral represent? 2. The partitions? 3. What part of the animal's body, then secreted the coral? 4. Compare the branching corals with Meandrina. 5. With the stone coral. 6. With the ornamental corals used in jewelry. 7. What does a polyp look like? 8. How do they differ?

Conclusions: 1. How do you explain the presence of coral rock in places away from our coast? 2. What is the result of adding hydrochloric acid.

Sketch: 1. Bit of branching coral. 2. Bit of stone coral. 3. Corallite with polyps.

Exercise 41.

Flatworms.

The Tapeworm

The adult tapeworm lives parasitically in the intestines of dog, man and many other animals. Two hosts are involved in its life history. One, where the early stages of development are passed, is generally a domestic animal the other may be man or another domestic animal.

Object: To study the external structure of a tapeworm.

Materials: Specimens of adult tapeworms may be obtained from any hospital and kept in alcohol for a long time in

the laboratory. The head is not so easy to get, so it is more convenient to keep stained slides with some of them.

Procedure: Examine adult tapeworms and observe the head with a dissecting microscope.

Observations: 1. What makes up the body of a tapeworm? 2. How do the anterior divisions differ from the posterior? 3. Which are the oldest? 4. Why? 5. Which mature first? 6. How do you know from your observations? 7. Compare the size of the head with that of the divisions. 8. What do you see at its top? 9. Below these? 10. How many? 11. What is the function of both structures? 12. How long is your specimen?

Conclusions: 1. Why is the tapeworm often difficult to get rid of? 2. How does it obtain its food? 3. Why can a single division be considered an individual. 4. List some ways by which a human individual might become infected with this parasite.

Sketch: 1. Head of tapeworm. 2. Few of the oldest divisions.

Exercise 42.

The Blood Fluke, Schistosoma Mansoni

Schistosoma Mansoni is a blood fluke. It was probably introduced into the islands of the Western Hemisphere through the medium of slave trade from Africa. The early stages in the life cycle are passed in the body of a specific pond snail and the escaping larva penetrates the skin of a human

being who might be wading in the pond. After travelling through the circulatory system of man the adult parasite is formed in the mesenteric veins, where oviposition finally occurs. The eggs are discharged into the intestinal lumen and are passed out with the feces. If they happen to be laid near a pond, they develop into a larva that penetrates the particular snail.

Object; To study the parasite of Bilharzia.

Materials: Arrangements can be made with the School of Tropical Medicine at San Juan, P. R., to secure slides containing different stages in the life history of Schistosoma and literature concerning cure and prevention may be obtained from the same institution.

Procedure: Examine all the material available. If possible, study some specimens of uninfected snails which are the intermediate hosts. Observe the adult parasites under low power. If slides with larva are available, examine also under low power. Study the literature obtained.

Observations: 1. Describe the larval stages observed. 2. Describe the adult. 3. How can you identify the snail concerned in this life cycle? 4. Briefly describe the whole life cycle.

Conclusions: 1. Make a list of preventive measures in regard to Bilharzia. 2. List the symptoms of the disease. 3. What is the cure, if any?

Sketch: 1. Graphical representation of the life history of Schistosoma Mansoni.

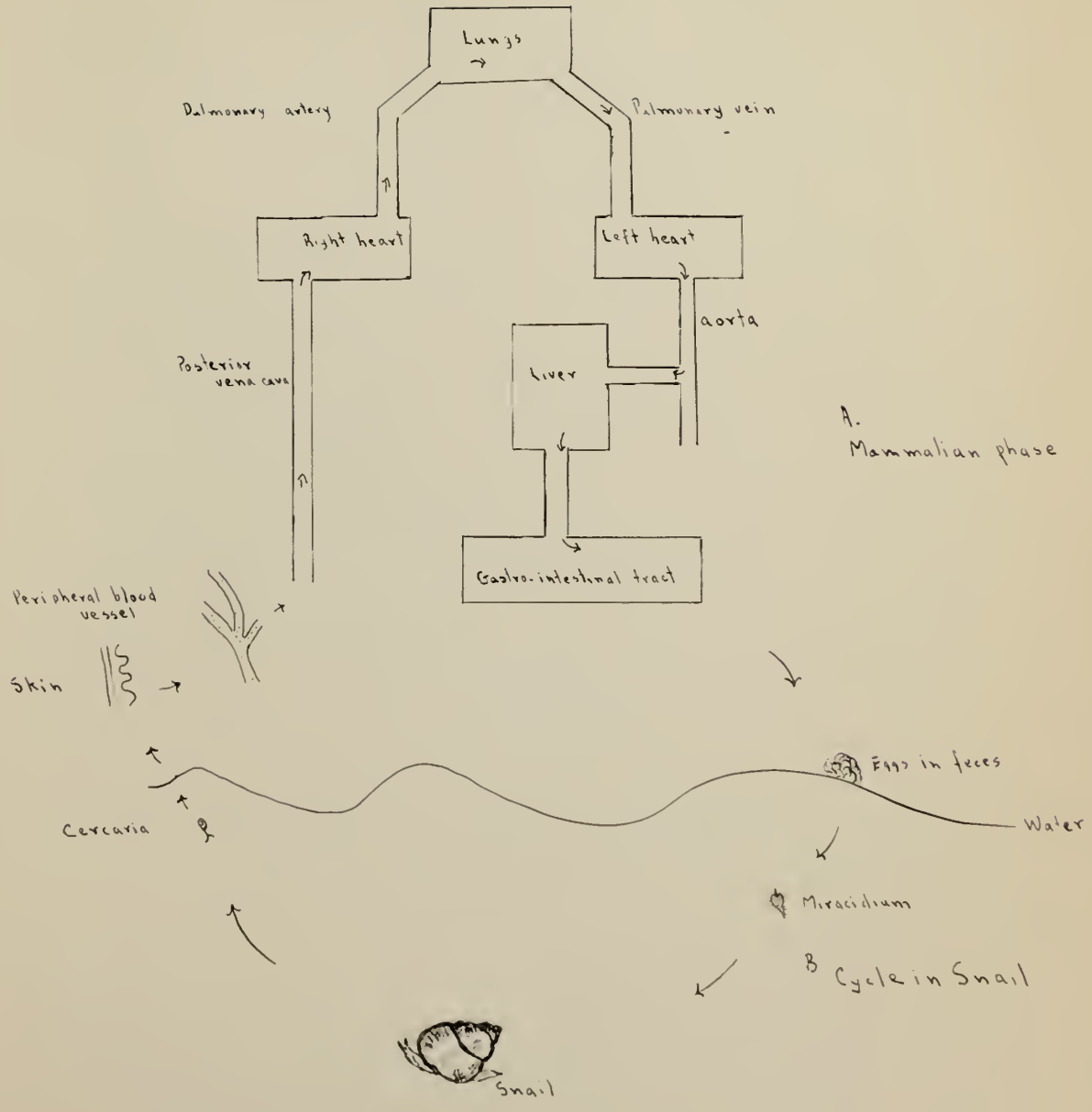


Fig. 10 Life History of Schistosoma Mansoni.

Exercise 43.

Roundworms.

Ascaris and the Hookworm.

Many roundworms are responsible for human diseases. Most common in the tropics are Ascaris lumbricoides and the hookworm which causes Uncinariasis. Both are intestinal parasites. The Ascaris feeds on the digested food of its host but the hookworm sucks blood from the intestinal walls. Ascaris enters an individual when the eggs are swallowed with unclean vegetables. Hookworm larvae penetrate the skin of barefooted people.

Object: To study the external anatomy of Ascaris and hookworm.

Materials: Specimens of Ascaris may be kept in alcohol for many years. Specimens of male and female hookworms may be obtained from the laboratories of the Department of Health at San Juan, P. R. Obtain literature and use it as in Schistosoma.

Procedure: Examine male and female specimens of Ascaris. Observe male and female hookworms with the dissecting microscope.

Observations: 1. How can you distinguish the sexes in Ascaris? 2. Compare the size of Ascaris and that of hookworm. 3. What is the difference between the sexes in hookworm? 4. How are the eggs passed from host to host in both parasites?

5. What characteristics differentiate roundworms from flat worms?

Conclusions: 1. How can you prevent Uncinaviasis? 2. What are the symptoms of the disease? 3. The cure? 4. What is the life cycle of the parasite? 5. Why is the hookworm more serious than Ascaris?

Sketch: 1. Male and female Ascaris. 2. Male and female hookworm.

Exercise 44.

Echinoderms

The Sea Urchin

Echinoderms are exclusively marine, and there are no true parasites in the group. They are characterized by an external calcareous skeleton, in many cases provided with spines. They move about by projections of a water-vascular system called tube feet.

The sea urchin (erizo), is common on our sea coasts where it lives in holes that it makes in the rocks.

Object: To study the external anatomy of the sea urchin.

Materials: Living specimens are preferred, and they can be kept for a few days in sea water in aquaria or jars in the laboratory. In any case, fresh material is easy to collect, even if it can not be kept alive. Tests are abundant along

our sea shores and they can be collected for study.

Procedure: Examine oral and aboral surfaces of the animal. If possible observe locomotion and movement of spines in living specimens. Add a drop of hydrochloric acid to the test.

Observations: 1. What is the general shape of the body? 2. Describe the spines in different parts of the body. 3. How are they attached? 4. What is in the center of the oral surface? 5. What projects from it? 6. How does the animal move? 7. What lies at the center of the aboral surface? 8. How many plates around this? 9. Which is the largest of them? 10. What do you find in these plates? 11. How many? 12. What are the knobs on the surface of the test? 13. The tiny openings in rows? 14. How many double rows? 15. Of what is the whole skeleton made up?

Conclusions: 1. What type of symmetry is possessed by the sea urchin? 2. To what conclusion do you come in regard to the number of parts in this animal? 3. What is the mechanism of locomotion in Echinoderms? 4. What is the substance of the test?

Sketch: 1. Oral view of sea urchin. 2. Central portion of aboral surface of test.

Exercise 45.

Molluscs

The Clam

Molluscs are soft bodied animals, but the great majority of them possess an external shell. To the Molluscs belong the snails, slugs, clams and oysters, octopuses and squids.

Object: To study the clam and other bivalve shells.

Materials: A few preserved specimens of the long-neck clam; bivalve shells that may be collected by the hundreds at any beach.

Procedure: Examine the specimens of the long neck clam and other bivalve shells. Test the shells with hydrochloric acid.

Observations: 1. How are the two valves of the shell fastened together? 2. Compare the anterior and posterior ends of the valve. 3. What is the prominence on the dorsal side? 4. What does it represent? 5. What are the lines below this? 6. What do they represent? 7. From what end does the siphon project? 8. What projects from the opposite end? 9. What are the large scars inside the shell? 10. What was the use of these structures? 11. How many layers do you see in the broken edge of the shell? 12. How do the two valves fit inside?

Conclusions: 1. What is the function of the siphon in the clam? 2. Of the foot? 3. Of what is the shell made up?

Sketch: 1. Side view of long neck clam. 2. Diagram of broken edge of shell.

Exercise 46.

Snails and Slugs.

Snails and slugs belong to a class of molluscs in which the locomotor organ, or foot, is located along the ventral side of the body. They possess a well developed head with eyes and tentacles. Snails possess a shell while slugs have a very rudimentary plate imbedded in the mantle.

Object: To study the external characteristics of snails and slugs.

Materials: Living pond and land snails and slugs.

Procedure: Study the animals while they are active. Observe the movements of the pond snail as it goes up and down the aquarium or battery jars. Let a slug pass over the sharp edge of a razor.

Observations: 1. What is the shape of the land snail shell? 2. How is it closed when the animal is inside? 3. What is the projection at the posterior end when the animal moves? 4. How many tentacles? 5. How does the animal use them? 6. What is at their tip? 7. What becomes of this when you touch a tentacle? 8. What lies on the ventral part of the head? 9. What difference is there between the structures on the head of a land and a pond snail. 10. How does the pond snail move in the aquarium? 11. What is the saddle shaped structure on the dorsal aspect of the slug.

12. How many tentacles does it have? 13. Where are the eyes? 14. What is located between the foot and the mouth? 15. What is left on the surface upon which the slug moves? 16. What happens to it when it passes over the sharp edge of a razor.

Conclusions: 1. How do you distinguish between a pond and a land snail? 2. Between a snail and a slug? 3. What are the functions of their mucous secretion?

Sketch: 1. Land snail. 2. Pond snail. 3. Slug.

Exercise 47.

The Octopus

Squids and octopus are marine molluscs in which the foot, divided into tentacles, surrounds the head. The octopus has no shell, while the squid has a vestigial, feather-shaped, horny plate buried under the mantle of the anterior surface.

Object: To study the general features of an octopus.

Materials: Small specimens of octopuses are obtained from small fisheries. They may be kept in formaldehyde solution for many years in the laboratory.

Procedure: Examine the external structure of the octopus.

Observations: 1. What is the shape of the body of the octopus? 2. How many arms? 3. With what are these provided? 4. For what purposes are they used? 5. What lies at the

center of the arms? 6. What do you see in it? 7. What is the projection on the underside of the head? 8. What do you see at the sides just above it?

Conclusions: 1. Describe the use of the siphon in the octopus. 2. How does it differ from snails? 3. From clams?

Sketch: 1. Octopus.

Exercise 48.

Annelids

The Earthworm.

Annelids are worms with segmented bodies. The segments or somites are not only visible externally, but they involve the internal anatomy as well. The nervous, digestive and excretory systems are very well developed in this phylum.

The earthworm is a terrestrial form living in burrows, where it remains most of the time, emerging only at night. It increases the fertility of the soil by casting nitrogenous wastes from its intestine into the upper layers of the ground.

Object: To study the external structure of the earthworm.

Materials: If possible some living earthworms should be kept in the laboratory. Preserved specimens are very easy to obtain and handle.

Procedure: Examine all the features and activities of the living earthworm.

Observations: 1. What is the shape of the body? 2. Inspect the two ends. 3. Describe its locomotion. 4. What is the texture of the body wall? 5. What do you feel when you pass your fingers slowly up from posterior to anterior end over the ventral surface? 6. What are these? 7. How many can you see on each somite with the hand lens? 8. What is their position? 9. What are they used for? 10. How does the animal react when you touch different parts of the body? 11. Try to find the reaction of different parts of the body to intense light with a flashlight and describe the result. 12. Count the somites. 13. How do the anterior differ from the posterior somites? 14. What do you see at about one-third of the way from the anterior end? 15. Where is the mouth? 16. What lies on top of it? 17. Where is the anus? 17. What are the slits on the ventral side of the 15th somite?

Conclusions: 1. How do you explain the reactions of an earth worm to mechanical stimulus? 2. To light? 3. Why are the locomotor organs so much reduced? 4. How can it breathe?

Sketch: 1. Anterior end of earth worm to 41st somite--Ventral view.

Exercise 49.

The Leech.

Leeches are aquatic or semi-aquatic worms almost entirely restricted to fresh water. They feed on small animals or suck the blood of vertebrates as external parasites. They are used

by physicians for blood-letting, and as a source of hirudin, a substance that prevents the coagulation of blood.

Object: To study the leech.

Materials: A few living specimens may be kept for years in the laboratory. They may be fed by allowing them to suck blood from frogs. A good feeding lasts for six months. They may be obtained from any small stream or from a drug store.

Procedure: Observe a living leech and notice how it attaches to a frog.

Observations: 1. Describe the two ends of the body. 2. What do you at each extreme? 3. What is in the center of each? 4. Where are the eyes? 5. What is the color of the dorsal side? 6. Of the ventral surface? 7. Describe swimming of the leech. 8. Describe its movement along a solid surface. 9. How does it feed?

Conclusions: 1. In what respects are earth worms and leeches similar? 2. How do they differ?

Sketch: 1. Ventral view of leech.

Exercise 50.

Arthropoda

The Shrimp

Arthropoda, or jointed-foot animals, is the largest phylum of the animal kingdom. Approximately four-fifths of

all known species of animals belong to this group. They are characterized by bilateral symmetry, segmentation of the body, centralization of the nervous system and a chitinous exoskeleton.

Crustacea is a class including crayfishes, crabs, lobsters and water fleas. They are aquatic, or inhabit very moist places so that their respiration is by means of gills.

Object: To study the external characteristics of the shrimp.

Materials: Living specimens of shrimps are easily obtained, since most boys are familiar with shrimp fishing, and they know how and where to get them readily. They are also available in the markets. They may be kept in the aquarium.

Procedure: Examine the external anatomy of a shrimp and observe the activities of the living specimen.

Observations: 1. What are the body regions of the shrimp? 2. How do you identify the separation between head and thorax? 3. What do you call the shield-like structure? 4. How far posteriorly does it extend? 5. Sidewards? 6. What is the difference in the segmentation of the first and last body regions? 7. What are the first pair of appendages? 8. How does the animal use them? 9. Describe the eyes. 10. Locate the mouth. 11. What are the claws? 12. How many walking legs? 13. What is the difference between the first and last two pairs? 14. What is the rea-

son for this? 15. What structures are attached to the ventral surface of the abdomen? 16. How many? 17. Use? 18. What forms the tail of the shrimp? 19. Locate the anus.

Conclusions: 1. Describe walking and swimming of a shrimp. 2. How does it dart backwards? 3. How do they react to other shrimps in the aquarium? 4. Where do they try to hide in it?

Sketch: 1. Side view of shrimp (extended abdomen)

Exercise 51.

Centipeds and Millipeds.

Centipeds live in dark moist places under stones and logs. Millipeds like the same moisture conditions, but prefer trees to the soil. Centipeds feed on insects, and they may bite man, but millipeds are herbivorous and incapable of inflicting wounds.

Object: To study millipeds and centipeds.

Materials: Centipeds and millipeds are abundant in the tropics and living specimens are easily obtained and kept in breeding cages.

Procedure: Examine and compare living millipeds and centipeds.

Observations: 1. Compare the shape of the body of a centiped to that of a milliped. 2. What are their body regions?

3. How many pairs of legs on each segment of a centiped? 4. On a milliped's? 5. What is the modification of the first pair of legs in a centiped? 6. Of the last pair? 7. What is the function of each? 8. What is the reaction of a milliped when you touch it? 9. What do they shed from their mouth? 10. How does the centiped react to touch?

Conclusions: 1. What are the means of protection of a centiped? 2. Of a milliped? 3. What is the truth about the popular idea of the relationships between mother and baby centipeds?

Sketch: 1. Dorsal view of centiped. 2. Side view of milliped.

Exercise 52.

The House Spider.

Spiders are found everywhere, and many annoy housekeepers with the silken webs that they are able to build so rapidly anywhere around the house. The big house spider is well known, and dreaded by many who hardly stop to think that it is harmless so far as man is concerned.

Object: To study the characteristics and behavior of the house spider.

Materials: House spiders may be kept in breeding cages while being studied. Be sure to get some with egg sacs.

Procedure: Observe living spiders. Examine a preserved specimen and find the eyes under a dissecting microscope.

Observations: 1. What are the body regions of a spider? 2. Compare its segmentation with that of other arthropods. 3. How many eyes? 4. How are they arranged? 5. How many pairs of appendages? 6. What is the structure of the first pair? 7. Use? 8. Describe the second pair of appendages. 9. What are the other four pairs? 10. How is the abdomen connected to the cephalothorax? 11. What do you find at the posterior end on the ventral side of the abdomen? 12. What are the openings in front of these? 13. What are the slits at the anterior end of the abdomen on this surface? 14. Where is the egg sac carried? 15. What do you find inside? 16. Why do you suppose that relatively few spiders emerge from the sac?

Conclusions: 1. List the characteristics which distinguish spiders from other Arthropods. 2. How do they resemble other Arthropods? 3. What does a spider use a web for?

Sketch: 1. Ventral view of spider. 2. Dorsal view of spider's head.

Exercise 53.

Scorpions.

Scorpions belong to the same class as the spiders. They are typical of tropical regions where they live in caves or hide under stumps. The common scorpion, camaroncillo, may sting humans. The whip scorpion, which

inhabits caves, is feared by many who call it the guaba. Scorpions are nocturnal in habits, and are quite beneficial, since they feed on spiders and insects.

Object: To study certain scorpions.

Materials: Scorpions and whip scorpions may be kept either alive or preserved. Whip scorpions may be extended in Ricker mounts and studied from these.

Procedure: Examine scorpions and compare them with spiders.

Observations: 1. Compare segmentation in scorpions and spiders. 2. How is the abdomen divided in the common scorpion? 3. What do you see at its very tip? 4. How many eyes? 5. Where are they arranged? 5. Describe the pedipalps. 6. How many legs? 7. Describe the pedipalps of the whip scorpion. 8. Why are they called whip scorpions? 9. How does the abdomen differ from that of the scorpion?

Conclusions: 1. Compare the means of paralyzing the prey in scorpions and spiders. 2. Why are scorpions grouped with the Arachnids? 3. What harm can a scorpion do to man?

Sketch: 1. Dorsal view of scorpion. 2. Dorsal view of whip scorpion.

Exercise 54.

Insects

The Grasshopper.

Insects are the most numerous animals in the world. They possess six legs, and generally two pairs of wings. Their bodies are divided into a distinct head, thorax and abdomen. Respiration is accomplished by a system of tubes called tracheae.

The grasshopper is found in all places, living among grasses. It is familiar to every one as the jumping insect observed as one wanders through our pastures.

Object: To study the details of the external anatomy of a typical insect, the grasshopper.

Materials: Take the students on a short trip through the nearest grassland. The school grounds in most cases is very suitable. Collect living grasshoppers, adults and nymphs and let the students watch their behavior while collecting them.

Procedure: Examine the grasshopper in the field and in detail in the laboratory.

Observations: 1. How does the grasshopper move? 2. What does it do with the hind legs when you hold it in your hands? 3. What comes out of its mouth? 4. Why did it disappear from sight when you were unable to grasp your

specimen? 5. Which wings are specially used in flight? 6. How does it behave when you put a stem of grass near its mouth? 7. How do the mandibles work? 8. Which legs are used for walking? 9. Which for jumping? 10. What is the difference in texture between the head, thorax and abdomen? 11. Why? 12. How do they use the antennae? 13. How many eyes? 14. What is their position on the head? 15. Are they all alike? 16. What is the appearance of the surface of the compound eyes under a magnifying glass? 17. What parts do you find aroung the mouth? 18. Which possess feelers? 19. How are they used? 20. How many segments make up the thorax? 21. What appendages are attached to each? 22. What are the parts of a leg? 23. What is the difference in structure between both pairs of wings? 24. How many abdominal segments are there? 25. Compare the first with the rest. 26. What structures do you find on the first? 27. How many spiracles on each body region? 28. Compare the last segment of a male with that of a female. 29. Why is the grasshopper a straight-wing insect?

Conclusions: List: 1. Methods of locomotion of a grasshopper. 2. Means of protection. 3. Sense organs.

Sketch: 1. Dorsal view of grasshopper, wings extended.

Exercise 55.

The Mosquito.

Mosquitoes belong to the order Diptera. They undergo

complete metamorphosis, and the immature forms, both larva and pupa, show special modifications for aquatic life. The adult female is blood-sucking, while the male feeds on plant juices, hence it is she who is responsible for the use of nets that cut down the sleepers' air supply in the tropics. They are most active at night.

Object: To study the anatomy and development of the common mosquito.

Materials: Wrigglers are easily obtained from standing water, and they may be kept in the laboratory for a few weeks before the exercise is performed in order to secure all the stages in their development. Adult mosquitoes may be placed on slides, with a drop of balsam and a cover glass, to be examined with the dissecting microscope.

Procedure: Observe the activities of the living larva and pupa in the aquarium. Examine them under the dissecting microscope. Study the adult maile and female.

Observations: 1. How does the larva move in the water? 2. How does it get air? 3. What do you see on the 8th abdominal segment? 4. At the tip of the abdomen? 5. Compare the head and thorax of the larva and pupa. 6. What is borne on the thorax of the pupa? 7. Use? 8. What are the paddles at the tip of the abdomen? 9. How many wings does the adult have? 10. What do you see along the veins? 11. Describe the posterior wings. 12. Compare the antennae

in both sexes. 13. Compare their mouth parts. 14. Describe the eyes.

Conclusions: (If possible) 1. Describe the emergence of an adult mosquito from the pupal skin. 2. How would you identify the female mosquito? 3. How could you destroy the larvae and pupae? 4. What is the most typical feature of Diptera?

Sketch: 1. Mosquito larva. 2. Mosquito pupa. 3. Mouth parts of adult female.

Exercise 56.

Modifications of Insect Mouth Parts.

Mouth parts of insects are usually considered by taxonomists for the separation of insects into orders. In general insects may have biting or sucking mouth parts. In most insects there are three pairs of mouth parts, namely mandibles, maxillae and labium. There may be an upper lip or labrum and a tongue or hypopharynx.

Sucking mouth parts may be used to obtain plant juices or to suck blood. In some insects there is a combination of chewing and sucking mouth parts.

Object: To study the modifications of mouth parts of a moth, female mosquito, cockroach, wasp and honey bee.

Materials: Specimens of the above mentioned insects.

Procedure: Dissect the mouth parts of the cockroach. Examine those of the moth with a hand lens and those of the

mosquito, wasp and honey bee under low power.

Observations: 1. How did the grasshopper use the labrum when you observed the living insect? 2. Describe the mandibles of the cockroach. 3. What lies below them? 4. What is their use? 5. What forms the floor of the pharynx? 6. What is its use? 7. Which parts bear palpi? 8. What parts are reduced or absent in the moth's mouth? 9. What forms the proboscis? 10. Whyis it so long? 11. Describe the proboscis of the female mosquito. 12. Compare with that of the male. 13. Where are the mandibles? 14. Describe the labium of the honey bee. 15. What is attached at either side of this? 16. What mouth parts form the proboscis? 17. Which are the shorter parts. 18. Compare the mouth parts of a honey bee and those of a wasp.

Conclusions: 1. List the mouth parts and use of each in the insects studied.

Sketch: 1. Mouth parts of cockroach. 2. Mouth parts of honey bee. 3. Front view of moth's head.

Exercise 57.

Insect Wings.

Insect wings are perhaps the best criteria for purposes of classification. Typically, there are two pairs of wings, although in some insects, like the Diptera, only the anterior pair is present, while in many parasitic or primitive forms,

wings are entirely absent.

As to their structure, insect wings show countless differences, although the general plan is the same for most of them. A wing consists of a flat skin fold divided by its veins into spaces known as cells.

Object: To study the structure of various insect wings.

Materials: Wings of butterflies, stink bugs, dragon flies, June beetles, house fly, mole cricket, wasps, and mosquito.

Procedure: Study the anterior and posterior wings of the insects called for and notice the special characteristics of each. Observe those of butterflies, mosquito, fly and wasps under low power.

Observations: 1. Describe a bit of butterfly wing under low power. 2. How do the anterior wings of the stink bugs lie over the abdomen? 3. Compare their base and apex. 4. What is the texture of those of the dragon fly? 5. Why are these animals such goof flyers? 6. Describe the anterior wings of the June beetle. 7. What is their use? 8. How is the posterior pair kept when at rest? 9. How many wings has a house fly? 10. Describe the posterior pair as seen under low power. 11. Compare the anterior and posterior pairs in the mole cricket. 12. What is the relation of the anterior and posterior wings of a fly when in use? 13. What is the advantage of this? 14. What do you see along the veins of a mosquito wing?

Conclusions: 1. How would you describe the wings of each of the order of insects studied in this exercise? 2. What do you suppose run through the veins of a wing?

Sketch: 1. Bit of butterfly wing under low power. 2. Anterior wing of stink bug. 3. Anterior wing of June beetle. 4. Posterior wing of house fly. 5. Anterior wing of mosquito. 6. Anterior and posterior wings of wasp.

Exercise 58.

The Metamorphosis of Insects.

Metamorphosis is the development of an insect from the time the egg is laid to the adult stage. It is, therefore, post-embryonic development.

Some insects are said to have no metamorphosis, because the form at hatching is essentially the same as that of the adult. In others there is a slight change, especially the development of wings and the increase in size of the body, but nevertheless, the newly hatched young, known as a nymph, greatly resembles the adult. In some there is a more marked change and the larva differs considerable from the adult. This larva, or naiad, is characterized by being aquatic, and therefore having modifications for living in the water. In the rest of the insect world there are at least three stages, which differ from one another morphologically and biologically, namely, larva, pupa and adult.

Object: To study the three chief types of metamorphosis.

Materials: Eggs and different stages in the development of

a grasshopper, dragon fly and a moth. (The stages in the development of the Sphinx moth or tobacco worm are easy to obtain).

Procedure: Examine and compare the successive stages in the development of the grasshopper, dragon fly and moth.

Observations: 1. Where are the grasshopper eggs to be found? 2. How can they be deposited in such a place? 3. How do the proportions of the body of the newly hatched nymph compare with those of the adult? 4. Describe the wings in this stage? 5. Compare this stage with a more advanced nymph. 6. Describe the mouth parts of the dragon fly naiad. 7. How can it get food? 8. What do you see in the wing buds? 9. Describe the result of adding a drop of methylene blue near the posterior end of the living naiad. 10. Explain. 11. Compare the naiad and adult as to antennae, eyes, wings and abdomen. 12. What kind of eyes, does the moth caterpillar have? 13. How many? 14. What kind of mouth parts? 15. How many true legs? 16. False legs? 17. Locate both. 18. What happens when you touch the abdomen of the pupa? 19. How does it differ from the larva? 20. What covers this stage? 21. What for? 22. What changes occur between the pupa and the adult?

Conclusions: Briefly state the changes undergone between one stage and the next in the types of metamorphosis studied.

Sketch: Larvae of: a. grasshopper
b. dragon fly
c. moth.

Vertebrates

Pisces

Exercise 59

The Fish

All the animals studied so far have one thing in common, namely the absence of a backbone. For this reason they are called Invertebrates.

Vertebrates, or animals with a backbone, fall into five classes, namely, Pisces, Amphibia, Reptilia, Aves and Mammalia.

The members of the first class, which includes the fishes, are covered by scales, possess gills for respiration, and are cold-blooded.

Object: To study the external anatomy and the activities of a fish.

Materials: Tropical fishes kept in the aquarium are best for this exercise.

Procedure: Observe locomotion, feeding and respiration of a fish in an aquarium. Examine the details of external anatomy in a preserved specimen.

Observations: 1. How many paired fins on a fish? 2. Locate them. 3. How many unpaired? 4. Where are they found? 5. How does the animal use each while swimming? 6. How does opening and closing of the mouth compare with the movements of the operculum? 7. What are the body regions of a fish?

8. How are the scales placed over the body? 9. Where are they modified? 10. What is found in this region? 11. What structures are found on the upper surface of the head? 12. What lie below the operculum?

Conclusions: 1. Describe the process of respiration in a fish. 2. How does the shape of the body adapt a fish to its environment? 3. How do they sense the approach of the enemy? 4. What structures of fishes correspond to the anterior and posterior limbs of other Vertebrates?

Sketch: 1. Lateral view of a fish.

Amphibia

Exercise 60

The Toad

Amphibia represent a transition from aquatic to terrestrial life. The early stages of development of a toad are spent in the water. The adult lives on land, although it returns at times to the water. Lungs develop in the land forms, but all larvae breathe by gills. In contrast with fishes, they have legs instead of fins, and the sense organs are more highly developed.

Toads have a dry rough skin and no teeth. They are beneficial because they feed on harmful insects.

Object: To study the metamorphosis of a toad.

Materials: Secure different stages in the development of a toad and keep them in an aquarium or large battery jar. Adult toads are to be found in every garden and they can be observed alive in breeding cages.

Procedure: Study the changes undergone by a toad in its development. Notice the external features of the adult. Place an adult toad in warm water.

Observations: 1. What are the body regions of the tadpole? 2. What structures do you see on the head? 3. What changes have taken place in the more advanced stage? 4. How does it breathe? 5. Which legs develop first? 6. What happens to the tail? 7. How does the young adult use both pairs of legs while in the water? 8. When it is outside? 9. What is the position of the mouth when the adult is under water? 10. Why? 11. Compare the upper and lower eyelids. 12. What is the disc behind the eyes? 13. Compare the parts of an anterior limb with those of your arm. 14. Of the posterior legs and yours. 15. What is the web? 16. Use?

Conclusions: 1. What distinguish Amphibia from Pisces? 2. Why is Amphibia considered a higher group than Pisces? 3. Trace the changes undergone by a toad from hatching to the adult form as observed in the laboratory. 4. What do you notice after the adult toad has been placed in warm water? 5. Conclusion?

Sketch: Side view of adult toad.

Reptilia

Exercise 61.

The Lizard

Reptiles are cold blooded vertebrates with a dry skin, which is covered with horny scales. To this class belong the lizards, snakes, turtles, alligators and crocodiles. They breathe by lungs throughout their lives.

Object: To study a typical reptile, the lizard.

Materials: Living lizards may be collected from all school yards a few minutes before performing this exercise. A few specimens of Gecko should be kept alive in the cages.

Procedure: Study a lizard externally and compare with a frog.

Observations: 1. What are the body regions of the lizard? 2. Describe the jaws. 3. What is the position of the eyes? 4. How are they protected? 5. How many eyelids are there? 6. Locate the tympanum. 7. How many toes on each foot? 8. How do they end? 9. Use? 10. How do they use their tails when they are about to begin moving? 11. What happens if you try to catch it by the tail? 12. How do they use the patch of skin on the throat? 13. What for? 14. Where do you find the Geckos? 15. At what time of the day? 16. What do they come here for? 17. Compare their color with that of the common lizard. 18. How do their digits terminate? 19. What is the special use of these? 20. What is the real truth

about the harm a Gecko may do?

Conclusions: List the characteristics that distinguish a lizard from a frog.

Sketch: 1. Side view of lizard. 2. Ventral surface of fore paw of Gecko.

Aves

Exercise 62

The Pigeon

Birds are land or semi-aquatic vertebrates with one pair of wings and one pair of legs as locomotor appendages. Their bodies are covered with feathers, and their toes have claws or nails. They are also characterized by being warm-blooded, oviparous and air-breathing.

Object: To study the external characters of a pigeon.

Materials: Living pigeons.

Procedure: Study the details of the external anatomy of a pigeon.

Observations: 1. How many kinds of feathers do you find in the pigeon? 2. How are the contour feathers arranged? 3. In what two ways do they serve the animal? 4. Where are the other types of feathers located? 5. What other epidermal structures are present in this animal? 6. What are its body regions? 7. Locate the nares. 8. How many eyelids? 9. What lies behind the eyes? 10. Compare with the

frog. 11. Why do you suppose the neck is so flexible? 12. Compare the wing with the fore leg of a frog. 13. What is the position of the first toe? 14. Use? 15. Describe the tail.

Conclusions: 1. How does the shape of a pigeon fit the animal for rapid locomotion? 2. To what structures in other Vertebrates studied do the feathers correspond? 3. What is their relation to the body temperature of birds? 4. Why is the absence of teeth an advantage in birds? 5. How can these animals grind the food? 6. Why is the greatest amount of muscular tissue on both sides of the breast bone?

Sketch: 1. Dorsal surface of extended wing. (Show various groups of feathers). 2. Outline of side view of the animal (do not include the feathers).

Mammalia

Exercise 63.

The Cat

Mammals are warm-blooded, air-breathing vertebrates which have a skin covered with hairs. With very few exceptions all mammals are viviparous, and suckle their young with milk secreted by mammary glands on the ventral body surface. The abdominal cavity is separated from the thoracic by means of a muscular diaphragm.

Object: To study the distinguishing external characteristics of a mammal, the cat.

Materials: One or two living cats placed in the breeding cages.

Procedure: Examine the external features of a cat.

Observations: 1. What are the body regions of the animal? 2. Compare the teeth with those of a reptile. 3. What do you see around the mouth of a cat which you did not find on the lizard? 4. How many eyelids? 5. What covers the surface of the lids? 6. Compare the ears with those of other vertebrates studied. 7. Where do you find the whiskers? 8. What is their function? 9. What is the relation of the length of the neck and that of the legs? 10. Why? 11. Which regions of the abdomen are most rigid? 12. Why? 13. What do you see on the sole of the foot? 14. Use? 15. What else besides these do you find on the hind foot?

Conclusions: 1. How is the body covering of the cat related to its temperature? 2. What special adaptations fit the cat for a predaceous life?

Sketch: 1. Front view of cat's head. 2. Inner surface of fore foot.

Anatomy and Physiology

Exercise 64.

Galvani's Experiment[1].

Luigi Galvani, while professor of anatomy at Bologna,

1. This experiment should be made as a demonstration.

accidentally discovered that living tissues, when activated, produce an electric current. He had some frog legs hanging from copper hooks in his laboratory. He noticed that when they accidentally came in contact with an iron railing they twitched.

Object: To reproduce Galvani's experiment.

Materials: unpainted iron clamp, copper hook, piece of zinc plate, Ringer solution, toad.

Procedure: Pith the brain and spinal cord of a toad. Open the abdomen, remove the viscera and locate the origin of the sciatic nerves. Cut away all the tissue anterior to these nerves. Remove the skin from the legs and moisten them with Ringer. Pass the copper hook under the nerves and by means of it hang the legs on the stand. Bring the zinc plate which has been clamped at the lower end of the stand in contact with the legs.

Observations: 1. Describe the result. 2. Why was an unpainted clamp used? 3. What tissues are activated in the experiment? 4. What part do they play in the electric current produced?

Conclusions: Compare the set-up of the experiment with the parts of an electric cell.

Exercise 65.

Action of Muscle and Nerve[1]

1. Note: This exercise may be performed as a demonstration by the teacher.

Stimulation of muscle and nerve.

Muscles and nerves are independently irritable, yet a muscle may be stimulated through the nerve that innervates it. Such stimuli may be heat, chemicals, electricity or mechanical.

Object: To study the reaction of muscle and nerve to different kinds of stimuli.

Materials: Toad, 10% Urethane, clamp, Ringer Solution, NaCL, glass slide.

Procedure: Anesthetize a toad by injecting 1 cc. of fresh urethane into the dorsal lymph sac. Open the abdomen and carefully remove the visceral organs. Strip the skin off the legs. Carefully remove the muscles of the thigh leaving the sciatic nerves unharmed. Finally remove everything but the gastrocnemius muscle of the lower leg. Keep the preparation well moistened with Ringer solution. Clamp the femur and support the nerve on a horizontal glass slide. Keep muscle and nerve moist with Ringer all the time. Pinch the end of the nerve. Apply a very hot needle to the same nerve. Dip it in strong salt solution. If possible stimulate with a mild electric current.

Observations: Describe the result of each of the above stimulations.

Conclusions: 1. What proves the irritability of the nerve? 2. Its conductivity? 3. What is a stimulus?

Exercise 66

Flexor and Extensor Muscles.

Muscles never act singly, but in groups. The two general groups are the flexors which bend a joint and the extensors which straighten it. When one group of muscles, for example the flexors, contracts the antagonistic group, the extensors, relax.

Object: To study antagonistic groups of muscles.

Materials: Secure or prepare a model of the muscles and bones of the arm.

Procedure: Flex your elbow while feeling the biceps of your arm. Extend the elbow while feeling the triceps. Examine the muscles and bones of the arm from the model.

Observations: 1. What happens to the biceps as you flex the elbow? 2. To the triceps? 3. To both when you extended the elbow? 4. What are the bones of the upper and lower arm? 5. To which is the biceps attached? 6. The triceps? 7. What is the difference between the two points of attachment of each muscle?

Conclusions: 1. What is meant by antagonistic? 2. Why is the biceps the antagonist of the triceps? 3. What is the origin of a muscle? 4. The insertion? 5. What brings about the action of muscles? 6. What general characteristic of the skeleton makes motion possible?

Sketch: Copy and label the diagram on the opposite page.

Fig. 11 Muscles of the Human Arm

Exercise 67.

The Heart

The heart is the pump that distributes the circulatory fluid through the vertebrate body. It is a two-chambered structure in fishes; three-chambered in Amphibia and most Reptiles and four-chambered in birds and mammals. It is muscular, and therefore capable of contraction and relaxation.

Object: To study the parts of a heart.

Materials: Secure two or three beef hearts from the butcher. Students may study these in groups. If a model of a human heart is available, it may be used to help locate the different parts. Red and blue pencils.

Procedure: Let the different groups study the parts of the heart externally. Cut open one of the specimens and let them observe the cavities inside.

Observations: Locate the following structures of the heart: 1. atria. 2. ventricles. 3. aorta. 4. pulmonary artery--size compared with aorta? 5. vena cavas. 6. pulmonary veins. 7. coronary vessels.

In the open heart: 1. Compare the thickness of the walls of atria and ventricles. 2. Compare thickness of the walls of ventricles. Why? 3. Origin of aorta and pulmonary artery? 4. What lies between auricles and ventricles? 5. Locate the semilunar valves? Use?

Conclusions: 1. Why is the heart a double pump? 2. What is the difference between the wall of an artery and a vein? 3, Why? 4. Trace the circulation of a drop of blood in the left ventricle out of and back into this chamber. 5. What is the only vein to carry oxygenated blood? 6. The only artery that carries de-oxygenated blood.

Sketch: 1. Longitudinal section of a heart. (diagram) Use red pencil for arterial circulation, blue for venous.

Exercise 68.

Capillaries

Most students know that blood flows in the blood vessels, but few have ever seen it flowing normally in these tubes. The smallest blood vessels or capillaries connect the arteries with the veins, so that the blood circuit in human beings is a closed one.

Object: To study blood flow in capillaries.

Materials: Toad, 10% urethane, dissecting kit, cork, microscope.

Procedure: Inject about 1 cc of fresh 10% urethane into the dorsal lymph sac of a toad to anaesthetize it. Carefully open the ventral wall of the body. Pin the mesentery across a circular hole cut out of a flat piece of cork. Keep the preparation continuously moist in Ringer solution. Observe the blood vessels under low power. The teacher may prepare one toad for each table. Examine a capillary under high power.

Observations: 1. How do you know which vessel is an artery and which a vein? 2. Where is the speed greater? 3. Why? 4. What is the velocity of the blood in a capillary as compared with that in an artery? 5. Why? 6. Where do the capillaries originate? 7. What is the relation of the width of capillary and size of the red blood corpuscle? 8. What is the shape of the red blood corpuscle? 9. What are the spots inside a corpuscle? 10. Compare with human corpuscles.

Conclusions: 1. List as many features as you can that distinguish a vein from an artery. 2. What do you think regulates the speed of the blood in the capillaries? 3. What is the relation of speed and amount of blood in capillaries?

Sketch: 1. Capillary showing origin and contents.

Exercise 69.

The Digestive Tract

The examination of the digestive tract of a toad is very satisfactory, since its structures are nearly like that of man. It will clarify many questions that exist concerning position and relation of parts.

Object: To study the digestive tract of a toad.

Materials: One toad for each pair of students, dissecting instruments, ether.

Procedure: Etherize the toads and let each pair of students open completely the ventral body wall. Observe and locate all

parts. Scratch the surface of the stomach with a needle, but be careful not to perforate it.

Observations: 1. Trace and locate all the parts of the alimentary canal of the toad beginning at the mouth. 2. What are the glands associated with this system? 3. Which is the largest organ in the whole tract? 4. What was the result of scratching the surface of the stomach? 5. What do you find between thorax and abdomen in man? 6. In the toad? 7. What other organs do you find in the abdominal cavity of a toad?

Conclusions: 1. What brings about the movement of food through the alimentary tract? 2. What else does this accomplish? 3. Where are the secretions of liver and pancreas discharged? 4. How? 5. What fixes the intestine to the dorsal wall? 6. What is the use of this?

Sketch: 1. Digestive tract of toad.

Exercise 70.

Mechanism of Respiration.

The structure of the chest cavity in man is such that its volume can be increased or decreased. The muscular diaphragm and the muscles that move the ribs bring about these changes in chest size. Since the chest cavity is closed with the trachea as its only opening, it follows that an increase in chest size will aspirate a quantity of air into the lungs through the trachea. This is called inspiration.

When the chest cavity is brought back to normal size, that is, decreased, air is forced out of the lungs in expiration because the lungs themselves contract elastically.

Object: To study the mechanics of breathing.

Materials: Bell glass with rubber stopper and Y tube, 2 rubber balloons, sheet of rubber, string. Framework with movable joints made of strong cardboard as shown by Figure 13 on the opposite page.

Procedure: Set up the apparatus as shown by figures. Pull the center of the rubber sheet down and release it. Move A towards B (See figure 13.)

Observations: 1. What does each of the following represent in the human body?

a. Upper part of Y tube? b. Arms of Y tube? C. Balloons? d. Rubber sheet? E. Bell glass?
2. What is the result of pulling the rubber sheet? 3. Of releasing it? 4. By which movement is the cavity increased? 5. What are A, B. C, in our bodies? 6. What was the result of moving A to B? 7. Why not move B to A?

Conclusions: 1. Describe the part played by diaphragm and ribs in respiration. 2. What do you think control the action of the muscles concerned? 3. What prevents the chest cavity from collapsing?

Sketch; 1. Chest cavity as illustrated by figure.

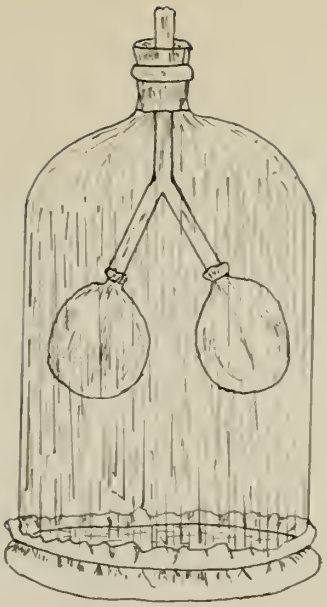


Fig. 12. Mechanical Duplication of Breathing

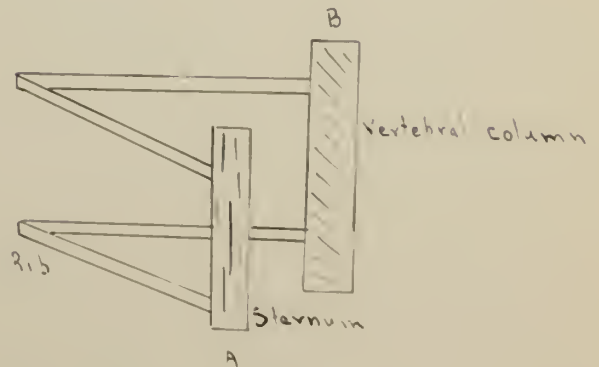


Fig 13. Rib Movements in Breathing

Carlson and Johnson, 1941, pp. 219 and 221.

Exercise 71.

Structure and Functions of Bones

Many individuals when thinking of bones believe that they are hard dead matter. They are largely composed of a hard intercellular substance, mainly phosphates, but they contain living cells as well. They serve mainly for the attachment of muscles, but they also give rise to red blood cells.

Object: To study the structure of a bone and the make-up of a skeleton.

Materials: Fresh bones (humerus) obtained from the butcher. Mounted skeleton of frog, pigeon or cat.

Procedure: Have the butcher split one or two humeri lengthwise for you. Examine the parts of it, and the position of bones in any mounted skeleton available.

Observations: 1. What is the difference in the nature of the shaft and epiphysis of the bone from the outside? 2. Inside? 3. Where is the cavity? 4. What does it contain? 5. What is the function of the red bone marrow at the ends? 6. What are the two main divisions of a skeleton? 7. What do you call the skeleton of the head? 8. What is the main function of the cranium? 9. What kind of joints do you find here? 10. Of what is the back bone composed? 11. How is the skeleton of the limbs attached to the axial skeleton? 12. What general type of joint do you find between the bones of the upper and lower arm? 13. Locate the breastbone. 14. Function?

Conclusions: 1. Why do broken bones heal? 2. What is the relation between the diet and bone formation?

Sketch: 1. Longitudinal section of humerus.

PART V

GENETICS AND VARIATION

Exercise 72

The Laws of Chance

Gregor Mendel is considered the father of heredity because his laws are the real basis of this science. He had a mathematical mind and, therefore, his experiments included careful counts and his conclusions were supported by mathematical evidence. This, perhaps due to his genius, places Mendel above all other previous workers in the field and, although much progress has since been made along this line, Mendelism is the starting point for all work on heredity.

Object: To study probabilities.

Materials: Every student must have a coin. Pea beans, red ink, cardboard boxes.

Procedure: Toss a coin 100 times and count the heads and tails. Stain a great number of pea beans with red ink the day before the exercise and let them dry. Place 100 white and 100 red beans and mix them in a cardboard box. Draw them by twos and record the draws.

Observations: 1. Record the heads and tails. 2. Add all the "heads" of the class. 3. Do the same with the "tails". 4. What is the ratio of heads to tails? 5. How does your own record compare with that of the whole group? 6. How many combinations can you get when using the beans? 7. What was the record of your draws? 8. Of the draws of the whole

class put together? 9. What is the ratio obtained from the class records?

Conclusions: 1. Make a general statement of the probabilities when the coin was used? 2. If red had been completely dominant over white in the beans used, what would have been the ratio obtained? 3. If incompletely dominant? 4. How does it compare with Mendel's law? 5. When do the laws of chance work in Mendelism?

Exercise 73.

Simple Mendelian Inheritance.

According to Mendel's law, if a cross is made involving one pair of contrasted characters, one of which is completely dominant over the other, the first generation will all show the dominant characteristic. The second generation obtained by selfing the first will show a ratio of three dominants for each recessive.

Object: To study a case of simple Mendelian inheritance in corn.

Materials: Obtain corn ears of the F2 generations of a cross between starchy-sweet; red-white and purple-white from any biological supply house.

Procedure: Count the grains in each corn ear available. Have each student make counts of at least 2 ears. Collect the countings and tabulate them.

Observations:

	1st ear	2nd ear	3rd ear	Total	Dominant	Recessive	Approx. Ratio
Red White							
Purple White							
Starchy Sweet							

Conclusions: Make a diagram of a cross between any of the above pairs of contrasted characters to the second generation.

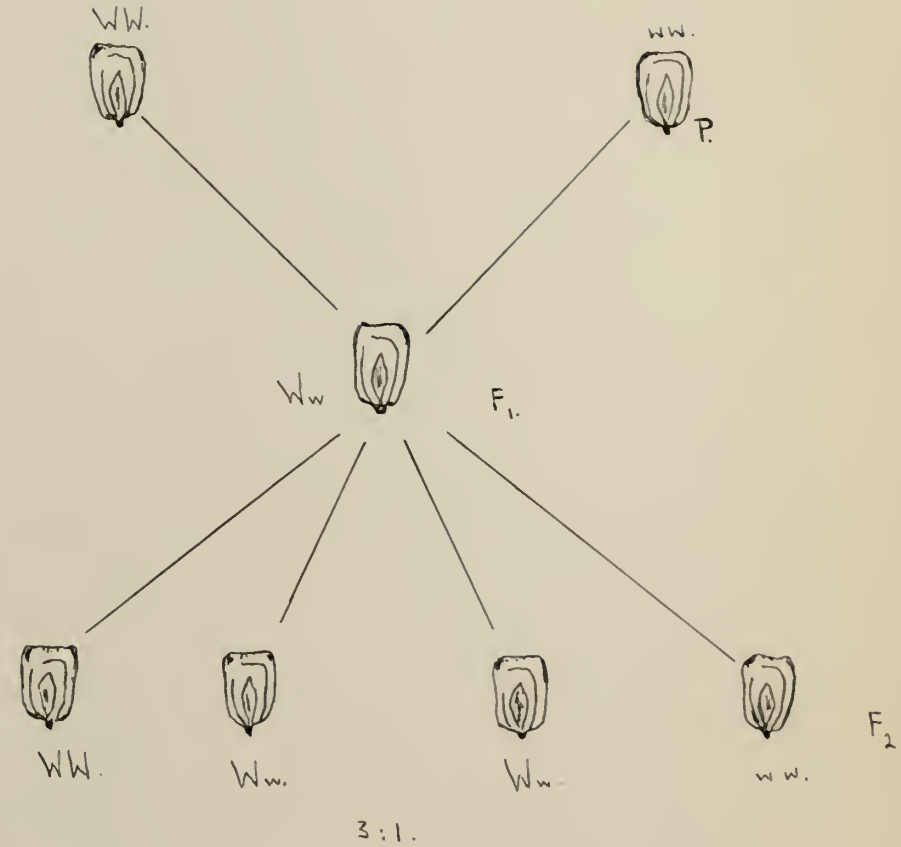


Fig. 14. Simple Mendelian Inheritance in Corn

PART VI

EVOLUTION

Exercise 74

Variation in Dragon Flies

The tendency for offspring to differ from their parents is known as variation. Variations may be of two types, namely, those which are hereditary, called mutations, and those which are non-hereditary, usually termed fluctuations. Variations may involve a change in structure or in function.

Object: To study variations in dragon flies (or mollusc shells.)

Materials: Collect as many specimens of adult dragon flies as possible; one hundred or more will give better results. These can be kept in insect boxes with naphthalene and increased in number of specimens year after year.

Procedure: Measure the length of the body of each dragon fly. Tabulate the lengths of the body and the number of insects having each length. Plot the results on graph paper. Let the horizontal axis represent body lengths and the vertical axis the number of specimens having each length. Draw the curve by connecting the points on the paper.

Observations: Prepare the graph.

Conclusions: 1. What is the average length of body? 2. What are the two extremes? 3. Which animals have a greater chance of survival? 4. Why?

Exercise 75.

Adaptations

Adaptation is the adjustment of a species of animal or plant to its environment. As the loaf is fitted to the pan, or the river to its bed, so is each species fitted to its' surroundings. If it were not so fitted, it would not live. Adaptive characters are preserved in heredity and guarded and intensified by selection.[1]

Object: To study the adaptations of some living forms to their environment.

Materials: Take the group to the nearest body of fresh water and collect plants and animals that show special modifications for different types of environment.

Procedure: Bring the collected material into the laboratory and divide it according to the following:

1. Plants in dry areas. 2. Plants in wet areas. 3. Living forms on the surface of the water. 4. Free swimming forms. 5. Bottom forms.

Fill in the table below.

Observations:

Name of Plant or Animal	Habitat	How fitted for habitat.

1. Jordan and Kellogg, Evolution and Animal Life (New York: D. Appleton and Company, 1908), p. 327.

Conclusions: 1. What is the importance of adaptations to the survival of a species?

APPENDIX

I. Stains and Reagents

A. Iodine solution.

Iodine . . . . . 1 gm.

Potassium Iodide . . . . 2 gm.

Distilled water . . . . 300 cc.

B. Fehling solution

Solution A

Copper sulfate . . . 17.3 gm.

Water. . . . . 250 cc.

Solution B

Rochelle salts . . . 86.5 gm.

Distilled water . . 125 cc.

Sodium hydroxide . .25 gm.

Mix equal parts of A and B just before using

C. Ringer solution.

Distilled water . . . . 1000 cc.

Sodium chloride . . . . 6.5 gm.

Potassium chloride . . .14 gm.

Calcium chloride. . . . .12 gm.

Sodium bicarbonate. . . .20 gm.

D. Formalin solution.

Dilute stock formalin to make five or six parts in one hundred parts of water. This is what is commonly meant by the term "five or six per cent" formalin.

II. General Laboratory Aids.

A. Pithing a toad. Hold the toad in your left hand. Move the nail of your right index finger until you find the depression between the skull and the first vertebra. Make a transverse slit in the skin at this point. Insert a blunt pithing needle into the cranial cavity and destroy the brain by moving the needle from side to side. Now bring the needle back and direct it posteriorly to destroy the spinal cord. See figure 15.

B. Preparation of striated muscle. Place 1/4 inch cubes of leg muscles of toad or small pieces of beef in 6% formalin for about 24 hours. From these pieces remove a shred no bigger than a heavy thread. With two pins tear this shred in a large drop of water. Cover with a cover glass and examine under high power. If a little Delafield's haematoxylin is used to stain the preparation, the nuclei may be observed.

C. Insect collecting.

1. Chloroform bottle. Place a small handful of rubber bands in the bottom of a jar and cover with chloroform. Let it stand overnight; pour out all remaining chloroform and wedge a piece of cardboard over the bands. Keep tightly closed when not in use. See figure 16A.

2. Net. Sew a piece of cheap marquisette in the form of a bag and fasten it to a heavy wire frame which is circular in form. Attach to a bamboo cane or a broom handle.

3. Relaxing chamber for softening dried insects so that they may be pinned or spread. It can be made as indicated by figure 16B.
4. Vials. These should contain 40% alcohol to be taken along in a collecting trip.
5. Paper folds. They are useful for keeping butterflies, dragon and damsel flies. If these are kept in the killing bottle they might be broken when other insects are put in. These also keep scales from rubbing off. Figure 17 shows how to make them.
6. Pinning. (Figure 18). An insect should be pinned after it has been killed and before it has dried. The usual method of pinning is to place the pin through the thorax. In the case of beetles the pin is thrust through the right elytra. Very small insects which can not be pinned may be mounted with glue on a heavy paper point and the paper pinned in the box. Be sure that when a box is filled, the insects or paper points are at the same height.
7. Collection pests. To prevent the destruction of preserved specimens by pests, put a small bag or fold of cloth with some naphthalene flakes or moth balls in a corner of the box.
8. Culturing. Any wide-mouthed jar covered with cheese cloth will do to keep living specimens

when breeding cages are not available in the laboratory.

D. Culturing Ameba. Ameba proteus is found in fresh water ponds and streams among aquatic plants or in the debris on the bottom of such bodies of water, specially among rotten leaves. Place small amounts of this material in finger bowls, cover with spring water and add two or three grains of uncooked rice. Do not place too much of the material in a single dish. Ameba will appear in successful numbers within a week or ten days.[1]

E. Culturing Paramecium. Paramecium is a form which is easily reared. From the bottom of a permanent pond the foul-smelling debris is taken and kept in a bowl barely covered with water at a temperature of approximately 75°F. About once a week a half-inch cube of fish is added to the bowl to maintain a food supply.[2]

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1. Galtsoff, Paul S. and others; Culture Methods for Invertebrate Animals, Ithaca: Comstock Publishing Company, 1937. p. 80.
2. Galtsoff, Paul S. and others (etc.) p. 120.

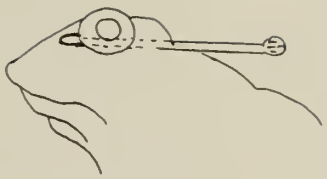
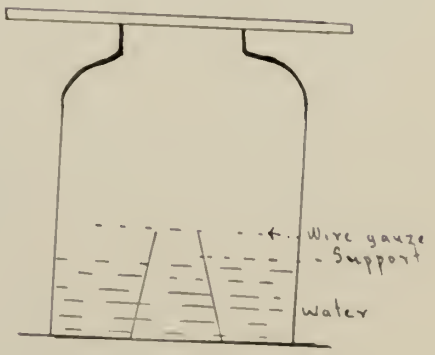


Fig 15. Pithing a toad

Miller and Blaydes, Pg 338

Fig 16 A. Insect Killing Bottle



B Relaxing Chamber

Miller and Blaydes, 1938, pp 160-161

Fig. 17. Paper Folds for Insects

Fig. 18. Pinning Insects

Miller and Blaydes, 1938; pg. 160, pg. 174.

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